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LIST OF CONTRIBUTORS

CAPON, WILLIAM A., D.D.S.
CUMMER, WILLIAM E., D.D.S., F.A.C.D.
ESSIG, NORMAN S., D.D.S.
FONES, ALFRED C., D.D.S.
FOX, FRANK A., D.D.S.
FURNAS, I. LESTER, D.D.S.
KENNEDY, EDWARD, D.D.S.
LeCRON, D. O. M., M.D., D.D.S.
MAUK, EDWIN H., D.D.S.
PEESO, FREDERIC A., D.D.S.
TRUEMAN, WILLIAM H., D.D.S.
TURNER, CHARLES ROOT, D.D.S., M.D.
WILSON, GEORGE H., D.D.S.

THE

AMERICAN TEXTBOOK

OF

PROSTHETIC DENTISTRY

IN CONTRIBUTIONS BY EMINENT AUTHORITIES

EDITED BY
CHARLES R. TURNER, D.D.S., M.D.
PROFESSOR OF PROSTHETIC DENTISTRY AND DEAN OF THE SCHOOL OF DENTISTRY,
UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA
AND
L. PIERCE ANTHONY, D.D.S., F.A.C.D.
ASSOCIATE EDITOR OF THE DENTAL COSMOS

FIFTH EDITION, THOROUGHLY REVISED

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THIS VOLUME IS DEDICATED TO

EDWARD CAMERON KIRK, D.D.S., Sc.D.,

IN RECOGNITION OF HIS EMINENCE IN DENTAL LITERATURE,
SCIENCE, AND EDUCATION

AND AS A

MODEST TOKEN OF THE REGARD OF HIS FRIENDS AND COLLEAGUES

THE EDITORS.

PREFACE TO THE FIFTH EDITION.

It has been fifteen years since the previous edition of this work was presented. The intervention of the World War and its aftermath served to delay plans which had been made for the earlier appearance of the present volume. Such extensive development in the science and art of dental prosthesis as has occurred even in the past few years has necessitated a complete revision of the former text. In order to give the principles and practice of this division of dentistry as full and complete treatment as seems desirable, it has been deemed wise to omit from the volume the chapters relating to the dental laboratory and its equipment, and the metals and alloys used in dental prosthesis. Newly prepared chapters on Partial Plate Dentures and Cast Metal Dentures, both treating their subject in a comprehensive manner, have been included as desirable additions. All the other chapters previously included have been thoroughly revised, and in some instances, almost completely rewritten.

Since the last edition was issued, four authors whose work appeared therein have died. With the exception of the two chapters prepared by Dr. Frederick A. Peeso and revised by him only a few weeks before his death, the work of deceased authors has been completely revised by others. It is believed that the contributions of the new authors whose names have been added to the staff, have greatly enhanced the value of the volume. Special attention is directed to the comprehensive treatment of Partial Dentures by Dr. Cummer, which is in itself a complete monograph on the subject.

The editor desires to express his appreciation of the forbearance and patience which the publishers, Messrs. Lea & Febiger, have exhibited during the long extended period which the work on this revision has consumed. He also wishes to acknowledge the splendid work of his associate, Dr. L. Pierce Anthony, who, in addition to assisting in the editorial work proper, has done all the proof-reading and has prepared the excellent index.

C. R. T.

Philadelphia, Pa.

LIST OF CONTRIBUTORS.

WILLIAM A. CAPON, D.D.S.

Assistant Professor of Dental Ceramics and Inlay Restoration, School of Dentistry of the University of Pennsylvania, Philadelphia.

WILLIAM E. CUMMER, D.D.S., F.A.C.D.

Professor of Prosthetic Dentistry and Dental Technology in the Faculty of Dentistry of the University of Toronto, Toronto, Canada.

NORMAN S. ESSIG, D.D.S.

Professor of Prosthetic Dentistry in the Philadelphia College of Dental Surgery of Temple University, Philadelphia.

ALFRED C. FONES, D.D.S.

Formerly Professor of Preventive Dentistry in the Columbia University Dental School, New York City.

FRANK A. FOX, D.D.S.

Assistant Professor of Prosthetic Dentistry, School of Dentistry of the University of Pennsylvania, Philadelphia.

I. LESTER FURNAS, D.D.S.

Professor of Prosthetic Dentistry in the School of Dentistry of the Western Reserve University, Cleveland, Ohio.

EDWARD KENNEDY, D.D.S.

New York City.

D. O. M. LE CRON, M.D., D.D.S.

Late Professor of Crown and Bridgework and Porcelain Dental Art in the Barnes Dental College. St. Louis. Mo.

EDWIN H. MAUK, D.D.S.

Professor of Prosthetic Dentistry in the University of California, San Francisco, Calif.

FREDERIC A. PEESO, D.D.S.

Late Director of the Dental Graduate School of Columbia University, New York City.

WILLIAM H. TRUEMAN, D.D.S.

Philadelphia.

CHARLES ROOT TURNER, D.D.S., M.D.

Professor of Prosthetic Dentistry and Dean of the School of Dentistry of the University of Pennsylvania, Philadelphia.

GEORGE H. WILSON, D.D.S.

Late Professor Emeritus of Prosthesis and Metallurgy in the Dental Department of Western Reserve University Cleveland, Ohio; Late Special Professor of Prosthesis in the University of Southern California, Los Angeles, Calif.

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PROSTHETIC DENTISTRY.

CHAPTER I.

THE HUMAN DENTAL MECHANISM; ITS STRUCTURE, FUNCTIONS, AND RELATIONS.

By CHARLES R. TURNER, D.D.S., M.D.

The oral cavity is situated at the beginning of the alimentary canal; it serves for the intake of food, and is provided with the means of its preparation for the subsequent stages of digestion and for assimilation. In the production of articulate speech, it serves as a resonating chamber for the vowel tones, and by alterations in its shape, through the action of the muscles of the tongue, lips, cheeks, and palate, it determines the character of the consonant sounds. The face is the principal seat of the expression of emotions in man, and as the mouth is one of its most mobile features, it participates prominently in the performance of this function. The loss of the teeth and the changes in the surrounding tissues which result therefrom are followed by an interference with the functions above enumerated, and by alterations of facial contour which greatly affect the personal appearance of their losers. As it is the purpose of dental prosthesis to prevent or remedy these changes, as far as possible, by the substitution of artificial apparatus for the lost tissues, a knowledge of the normal operation of the several functions thus affected is of fundamental importance to the study of the subject. This chapter aims, therefore, to treat of the functions of the dental mechanism from this point of view. It will discuss the manner in which they are affected by the loss of the teeth, so that the problems arising in tooth replacement may be solved the more satisfactorily.

The most important function of the mouth, from the standpoint of the body economy, is the preparation of food for the subsequent stages of digestion. Food stuffs of various degrees of physical consistence are introduced into the cavity, their solid portions are cut, crushed or ground, mixed with the saliva, and are then carried into the stomach. As this is largely a mechanical process, we shall first take an analytical view of the mechanism by which it is accomplished.

THE HUMAN DENTAL MECHANISM.

Architecturally considered, the masticating mechanism consists of a fixed base, the upper jaw, supporting the upper teeth, against which is operated a movable arm, the lower jaw, also equipped with teeth so placed as to oppose those of the upper jaw. The teeth serve as the armament of the apparatus, affording hard surfaces between which the food is crushed. Muscles extending between the fixed and movable elements of the apparatus, and so disposed as to be capable of exerting great pressure in approximating them, furnish the active forces of the mechanism; while the walls of the oral cavity, which contain the crushing apparatus, serve to confine the food, and the lips and cheeks and the tongue further assist the process by keeping the food between the crushing surfaces.

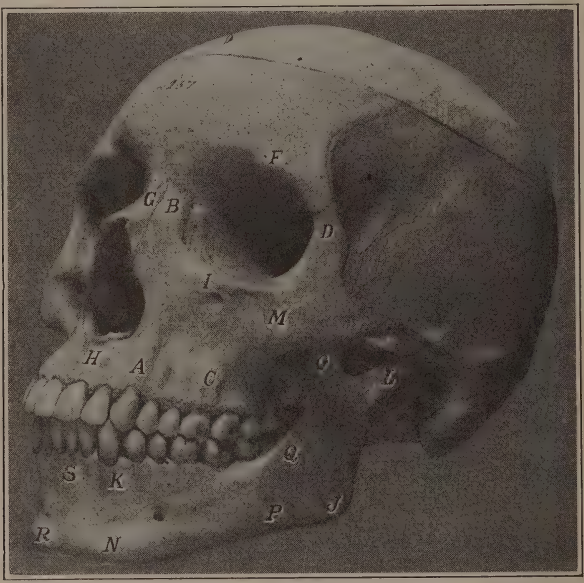

Fig. 1.—Architectural construction of skeletal portion of masticating apparatus: The fixed base and movable arm; columns, arches and buttresses of the fixed base; fronto-nasal column, *A B;* zygomatic column, *C M D;* pterygoid column (only partly visible), supra-orbital arch, *B F D;* infra-orbital arch, *B I D;* upper nasal half arch, *B G;* palatal arch (not shown); lower nasal arch, *A H;* large molar arch, *A C;* molar buttresses (descending from *M);* pterygoid arches (not shown); columns and arches of the movable arm; mental column, *N K;* coronoid column, *P Q O;* condyloid column, *J L;* external oblique column, *Q N.* (From a photograph of specimen No. 4237, Wistar Institute of Anatomy.)

The Fixed Base.—The axial skeleton of the body consists of the vertebral column, the skeletal basis of the trunk, which supports upon its upper extremity, the skull. The cranial portion of the skull receives direct support at the atlo-occipital articulation, the facial portion being in turn suspended from the anterior surface of the cranium. The superior maxillæ, united in the median line and lodging the upper teeth, are supported upon the cranium through articulations by the frontal, lachrymal, ethmoid, palate, vomer, and malar bones, and constitute the fixed base of the masticating mechanism.

The arch-shaped alveolar process (Fig. 1), containing the teeth which receive the impact of mastication, is supported upon the cranium by three pairs of columns or buttresses, reinforced by several secondary arches and braces (Burchard). The columns are the fronto-nasal, ascending from the position of the canine tooth to the inner margin of the orbit, and reaching the frontal bone; the zygomatic, extending from the position of the first molar tooth through the outer margin of the orbit; and the pterygoid, ascending from the molar region upward and backward to the sphenoid. These columns are strengthened by braces as follows: The supra-orbital arch, the infra-orbital arch, the upper nasal half arches, the palatal arch, the lower nasal half arches, the large molar arch, the molar buttresses, and the pterygoid arches. It will be noted that the articulations of the maxillæ, notably those with the malar bones, are disposed to resist stress operating from below. This fixed base is admirably constructed to receive, resist and dissipate force received from below so that the brain and delicate sense organs contained in the face will not be unduly shocked during mastication, and is "erected to endure the shock of impact from all sorts of biting, *i. e.*, cutting, tearing, crushing, triturating with longitudinal and transverse motions, and to resist and stand firm during all the varieties of movements incident to mastication."

The Movable Arm.—The lower jaw consists of an arch-shaped horizontal portion, the body, which supports the lower teeth by means of its alveolar process, and terminates posteriorly in two vertical branches, the rami, by which it articulates with the cranium. The muscular apparatus by which the mandible is raised is attached in part to the cranium and in part to the strong zygomatic arch, and is not concentrated upon one point on the mandible, but its attachment thereto is distributed over an area between the condyle and the middle third of the body of the mandible. The resultant line of its action when the teeth are in contact passes slightly behind the coronoid process of the mandible and approximately through its anatomical angle (Fig. 2, *M*). The mandible is bent at this point so that the general plane of the teeth when in occlusion is perpendicular to the line of action of the levators. By this arrangement the teeth may best oppose the action of the levators, since they resist force best which acts at a right angle with the general plane of their occlusal surfaces. The resistance offered by the food between the teeth varies for any given food with its position on the teeth. For a food of given resistance the farther back in the mouth it is placed, the less will be the muscular force necessary to overcome the resistance.

The point of the origin and insertion of the muscles is fixed, but as the position of the fulcrum changes in its relation to the former of these during the movements of the jaw, the length of the power-arm of the lever is affected, and the resistance which may be overcome by the muscles varies in accordance therewith. The more nearly the jaws are together, the longer is the power-arm, and hence it will be found that the more nearly they are approximated, the greater will be the power which the muscles may exert. From these several facts it will be seen that the lever is of the type best suited to the lifting of a heavy weight slowly through a short distance.

To resist the stress put upon it in these operations the mandible is well designed structurally (Fig. 1). It may be considered as composed of several pairs of bony columns. The vertical columns are the mental column, extending perpendicularly upward from the lower margin of the body to the position of the canine tooth, the coronoid, ending in the coronoid process, and the condyloid parallel to it and ending in the condyle. These are bound together by the long body columns of the external and internal oblique lines. Cryer[1] has pointed out the architectural strength of the body of the bone, the cortical U-shaped portion of the exterior being bound together by the internal cancellated tissue.

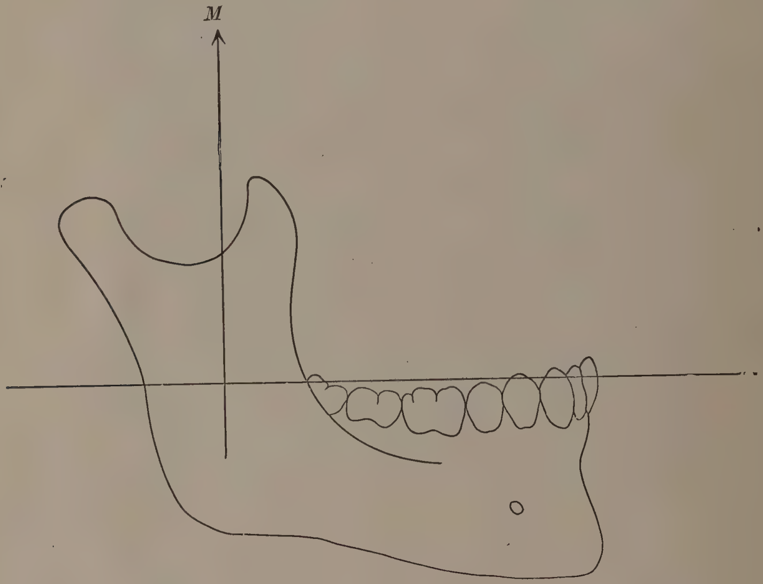

Fig. 2.—Diagram illustrating line of action of levators of lower jaw.

The fulcrum of the lever rests upon the base of the skull where the bone is thick and dense and well designed to resist the force put upon it, and the joint itself is provided with intervening soft tissues as a means of lessening the shock of activity.

The Temporo-mandibular Articulation.—This joint is a condylarthrosis, the structures taking part in it being the glenoid fossa of the temporal bone and the condyle of the lower jaw, together with the proper and accessory ligaments, and the tissues interposed between the bones. It permits both a sliding of the condyle over the surface of the fossa, and a rotation of the mandible about an axis passing through the two condyles.

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[1] Internal Anatomy of the Face.

The Glenoid Fossa.—This is an oblong cavity (Fig. 3) on the under surface of the squamous portion of the temporal bone, its concavity being directed downward. It is bounded anteriorly, by the eminentia articularis (the anterior root of the zygoma), externally, by the middle root of the zygoma and the auditory process, and posteriorly, by the tympanic plate of the petrous portion of this bone. The Glaserian fissure which runs across the cavity divides it into two unequal portions, the posterior third being rough and lodging a portion of the parotid gland, the anterior two-thirds being smooth and covered in the recent state with a dense fibrous tissue and receiving the condyle of the lower jaw. Of the articular portion of the fossa the distal part is the most concave and is also the most elevated. From this point it slopes downward and forward to the crest of the eminentia articularis, furnishing a surface over which the condyle glides in the forward excursions of the mandible. The shape of the cavity varies with different nationalities, with different individuals, at different ages in a given individual, and sometimes on both sides of the same individual. The principal variations are: (1) In size and general concavity, in correspondence with the shape of the condyle; (2) in extent of surface from the most concave portion to the eminentia articularis; (3) in its inclination. The outlines in Fig. 4 show the curve of this cavity obtained from skulls after the method of Tomes and Dolamore. The fossa becomes flattened in old age by the partial disappearance of the eminentia articularis, or it may be changed by the pull of the muscles upon the

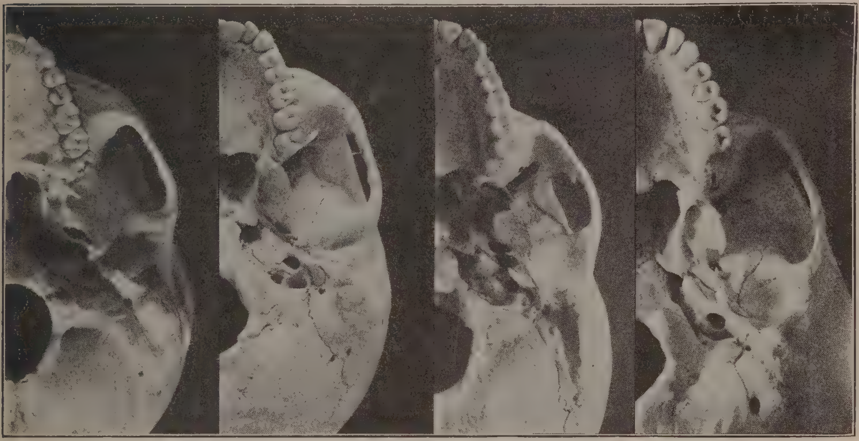

Fig. 3.—Left glenoid fossæ of four skulls, showing differences in form.

mandible in their effort to bring into occlusion teeth in the opposing jaws that may be widely separated in location.

The condyle of the lower jaw (Fig. 5), is the upper extremity of the ramus which fits into the glenoid fossa. It consists of the neck by which it is joined to the ramus, and the head which is ovoid and oblong in shape corresponding to the fossa into which it fits. Its long axis is transverse, and if extended would meet that of the other condyle approximately in front of the foramen magnum, while its short axis prolonged would meet that of its fellow approximately at the symphysis menti. It is convex from before backward and from side to side. The articular surface extends to a lower level posteriorly than anteriorly to permit rotation of the jaw about the condyles. The articular surface of the condyle may be said to present two faces, an upper or anterior and a lower or posterior, the division between them not being distinctly marked. It is covered with a thin covering of fibrous tissue which serves to even up its surface without altering its shape.

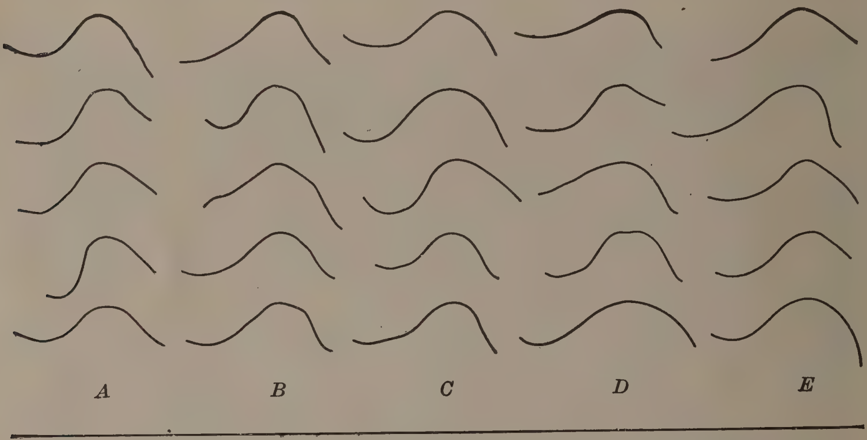

Fig. 4.—Outlines of glenoid fossæ obtained by the method of Tomes and Dolamore. The heavy base line is parallel to a line drawn from the anterior nasal spine to the floor of the external auditory meatus. All the fossæ outlined were on the left side of the skull. *A*, from skulls with typical dentures; *B* and *C*; from skulls with several teeth missing; *D* and *E*, from edentulous skulls.

There is a definite relation between the shape of these parts and the movement of which the lower jaw is capable The shape of the condyle and the fossa, which more or less accurately correspond in size, differs greatly in different individuals. A long narrow condyle (Fig. 5, *D*) is received into a groove-like fossa, and permits more easily the up and down motion of the jaw, in which the joint acts largely as a hinge.

A flattened condyle is received into a shallow flattened fossa (Fig. 5, *A*) and readily permits the lateral excursions of the mandible. Intermediate forms are shown in *B* and *C*, Fig. 5., and all these are normal variations in the shape of the condyle.

Interposed between the head of the condyle and the fossa and separated from each by a synovial sac is found the interarticular fibro-cartilage or meniscus (Fig. 6). This is a disk-like cartilage, ovoid in shape, its upper surface concavo-convex from before backward to correspond to the shape of the fossa. It is concave in front where

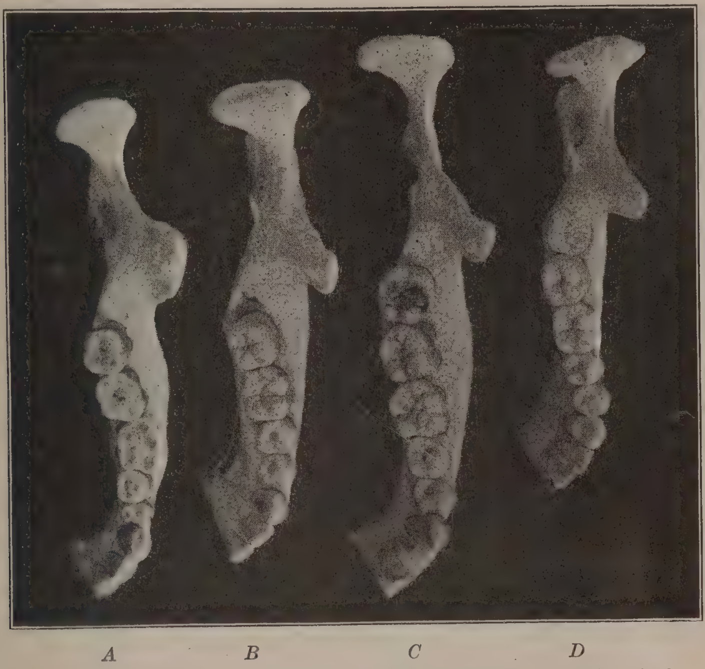

FIG. 5.—Left condyles of four mandibles, showing normal variations in form.

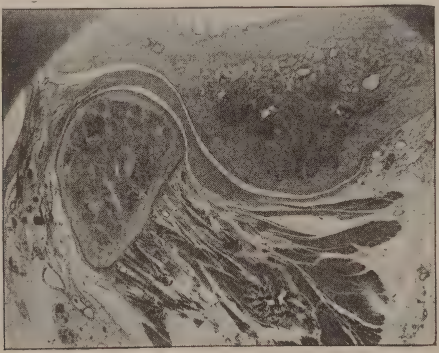

FIG. 6.—Photomicrograph of section of adult mandibular articulation. (Prentiss.)

it comes in contact with the eminentia articularis, and convex posteriorly where it fits into the concavity of the fossa. On its lower surface it is concave. The posterior border is nearly twice as thick as the anterior, while the external border is thicker than the internal. In the normal resting bite the cartilage covers only the upper anterior portion and the top of the condyle which it surmounts, while the posterior aspect of the articular surface of the condyle is not in contact with it, but with the posterior part of the capsule. In the forward and lateral excursions of the mandible, the cartilage and condyle leave the distal part of the fossa together, or in rare cases the condyle goes forward over the surface of the cartilage. The meniscus is attached to the condyle most intimately internally and externally, which causes the

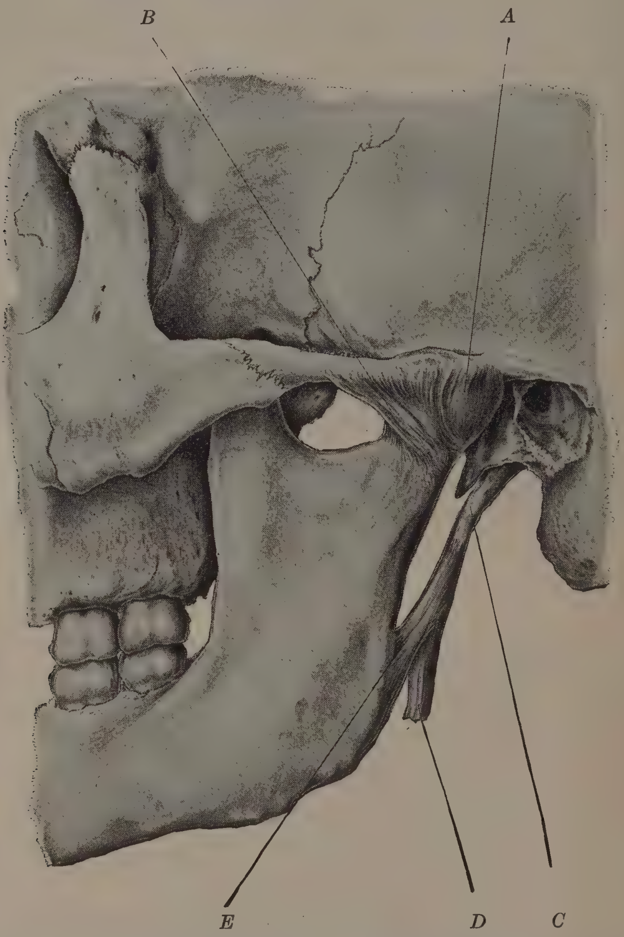

Fig. 7.—Ligaments of temporo-mandibular joint (external view). *A*, capsular; *B*, external lateral; *C*, stylo-maxillary. (Deaver.)

cartilage and condyle to go forward together and yet does not prevent a rotation of the jaw about the condyles. The contraction of the external pterygoid muscle, which is attached to the anterior edge of the cartilage, as well as to the neck of the condyle, is responsible for its forward movement. The synovial sacs (Fig. 6) above and below the disk, permit the gliding and rotating movements of the joint. The cartilage always furnishes a base upon which rotation takes place and is always interposed between the condyle and the fossa.

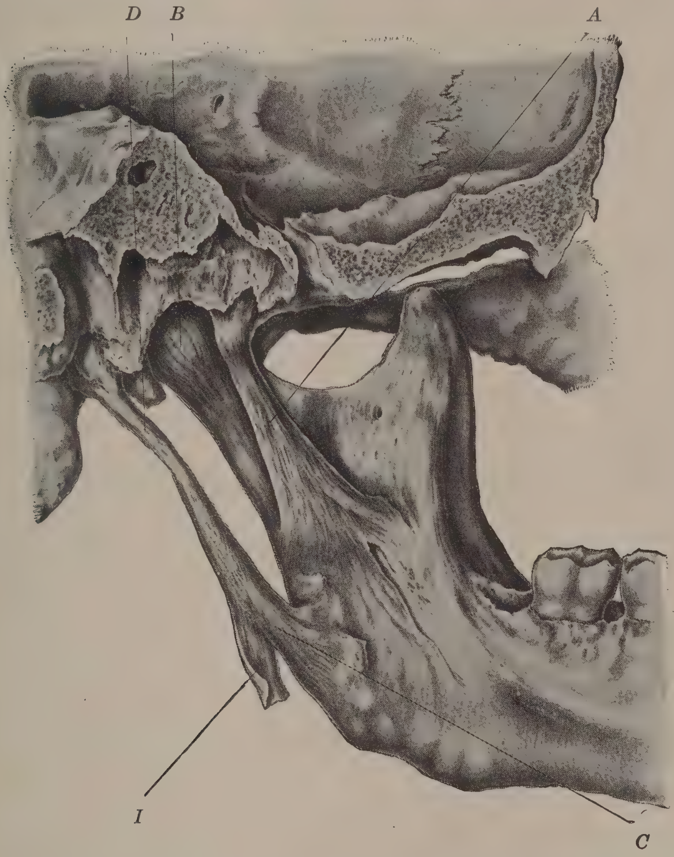

Fig. 8.—Ligaments of the temporo-mandibular joint (internal view). *A*, long internal lateral or spheno-maxillary; *B*, short internal lateral; *C*, stylo-maxillary. (Deaver.)

The ligaments of the joint (Figs. 7 and 8), are the capsular, the external and internal lateral ligaments, which are only thickenings of the capsular, and several accessory ligaments.

The capsular ligament is attached above to the anterior border of the root of the zygoma, behind to the bottom of the glenoid cavity a little in front of the Glaserian fissure, on the outside to the zygomatic tubercle and the longitudinal root which follows it, and on the inside to the base of the spine of the sphenoid. It is attached below around the neck of the condyle; anteriorly, immediately below the articular surface, posteriorly, to a line 3 to 4 mm. lower. This permits the articular surface of the condyle to be in relation with the cartilage during any of its normal movements. The internal surface of the capsular ligament is intimately connected with the cartilage around its periphery where the two come in contact, thus dividing the cavity into two portions.

The capsular ligament consists mainly of vertical fibers, and is thin, particularly in front, where it gives attachment to some fibers of the external pterygoid muscle. Posteriorly there are some elastic fibers attached a little anterior to the Glaserian fissure, and passing downward are attached to the cartilage and the neck. Sappey[1] says these contribute to limit the forward displacement of the cartilage and condyle and serve to bring the former back when the condyles retreat into the fossæ.

The principal suspensory ligament is the external lateral, which is attached above to the outer surface of the zygoma and to the rough tubercle on its lower border, and below to the outer surface and posterior border of the neck of the condyle. It is a stout thick ligament, broader above than below, its anterior fibers being the longer, and anterior to the horizontal axis of the condyle. By reason of its attachment it assists in compelling a forward movement of the condyle during depression of the jaw.

The internal lateral (or short internal lateral) is shorter than the external, is inserted into the back of the neck of the condyle, and has longer outer fibers.

The spheno-maxillary (or long internal lateral ligament) is attached to the alar spine of the sphenoid and extends to the spine on the mandible internal to the inferior dental foramen.

The stylo-maxillary is a specialized band of cervical fascia, extending from the styloid process to the ramus a little above the angle of the jaw. According to Prentiss[2] the lower part of this ligament prevents backward displacement of the condyle while the upper part prevents its forward displacement.

It will be noted that the ligaments of the joint, while permitting great freedom of movement in certain directions, bind the condyle firmly in the fossa, and that the groove-like character of the socket limits its movement in certain directions. Movement distally is resisted by the posterior wall of the cavity, the extent of compressibility of the intervening soft tissues being the limit of movement in this direction. Movement forward is permitted, as we have seen. Only slight outward movement is possible and movement of the condyle inward is possible only to the extent permitted in rotation of the jaw about the other condyle. Any force tending to separate the contact between the condyle, cartilage, and fossa is resisted by the joint ligaments proper, notably the external lateral, so that such movement is permitted only to the amount to which these ligaments may be stretched. For all practical purposes the condyle and fossa may be said to be always in contact through the medium of the interposed cartilage, for the reason that the usual forces operating upon the jaw tend to press the condyle into the fossa and not to separate them. In edentulous patients where the fossæ are very flat, the ligaments seem to become lengthened, thus permitting a large range of movement to the jaw. The soft tissues interposed between the bones are slightly compressible, but this factor is so small in amount as to be practically negligible in estimating the path of the condyle during the movements of the jaw. Therefore within the restriction offered by the ligaments, this path will be determined, so far as the joint is concerned, almost solely by the form of the glenoid fossa. Hence it will be seen that there is a definite relationship between the movements of which the lower jaw is capable and the character of the temporo-mandibular articulation, although it must be remembered that this is only one of the factors which determine the character of these movements.

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[1] Testut: Traité d'anatomie Humaine.

[2] Dental Cosmos, vol. **60**, p. 507.

The Muscles.—The muscles attached to the lower jaw and producing its movements are the temporal, masseter, external and internal pterygoids, ordinarily classed as the muscles of mastication because they are the active agents in this process, together with the mylo-hyoid, the genio-hyoid, the digastric and the platysma myoides. With the exception of the last they are arranged in symmetrical pairs usually operating simultaneously in the principal movements of the jaw, although each is capable of independent contraction. Prentiss has called attention to a muscle found well developed in cats, and present as a small muscle in man to which he has given the name pterygo-meniscus. This, he asserts, is largely responsible for the inward movement of the condyle. The temporal muscle (Fig. 9), the principal levator of the mandible, arises from the whole of the temporal ridge and fossa and converges to be inserted into the coronoid process. The masseter, short, quadrilateral, thick, and powerful has two planes of fibers, the external, arising from the malar process of the superior maxilla, the outer surface and anterior two-thirds of the zygoma, and inserted into the lower half of the ramus and the angle of the jaw; the internal layer, arising from posterior third of the zygoma and attached to the upper portion of the ramus. The internal pterygoid is also thick and quadrangular in shape, extending from the pterygoid fossa, its origin, to the inner surface of the ramus and the angle of the jaw. The external pterygoid arises by two heads, one from the under surface of the great wing of the sphenoid, the other from the tuberosity of the maxillary bone and the palate bone. The fibers pass almost horizontally backward and outward to be inserted into the neck of the condyle and the anterior margin of the interarticular fibro-cartilage. With the exception of the last-described muscle, it will be seen from their points of attachment that they serve largely to elevate the mandible into contact with the maxillæ by rotating it about the condyle. They arise either from the cranium or from the strong zygomatic arch, and are attached to the lower jaw at points between the temporo-mandibular articulation and the teeth. They are short and powerful, and capable of exerting considerable force. The function of the external pterygoids acting is to pull the condyle forward and downward over the surface of the glenoid fossa, and to so adjust the cartilage that it is always interposed between the condyle and the fossa. The external pterygoid on either side contracting independently of its fellow, and in conjunction with the pterygo-meniscus, serves to pull its condyle downward, forward and inward, thus rotating the jaw about the opposite condyle.

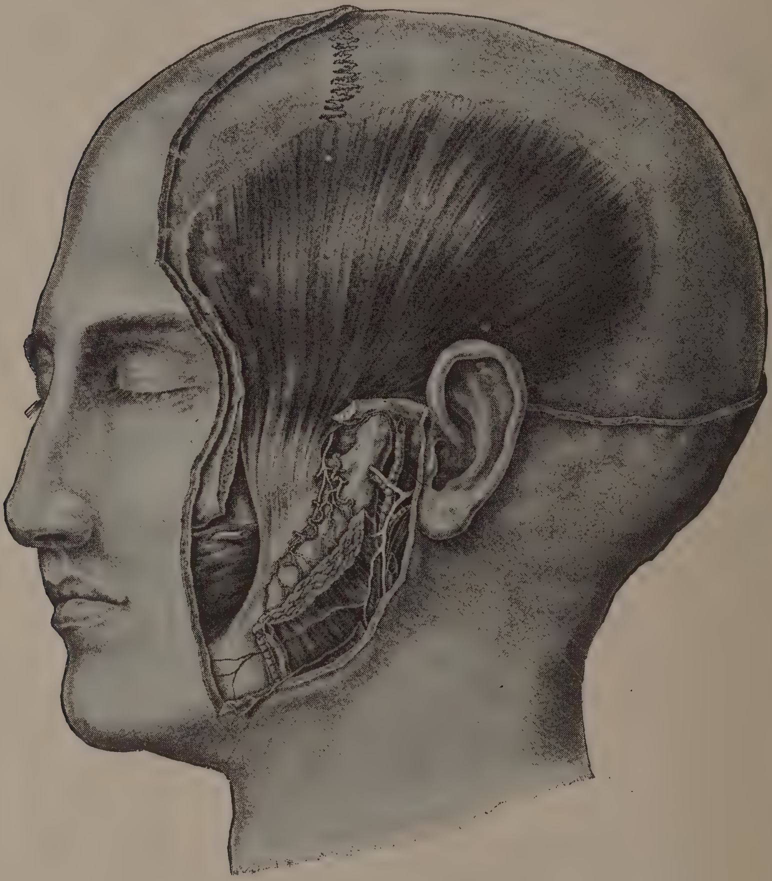

FIG. 9.—Temporal muscle. (Deaver.)

The depressor muscles are mainly attached to the forward end of the mandible. The genio-hyoid and the anterior belly of the digastric are inserted into its inner surface near the median line; the mylo-hyoid being attached to the ridge of that name. They operate from the hyoid bone, which must first be fixed by the omo-hyoid, sterno-hyoid, and thyro-hyoid muscles. The platysma myoides is attached below to the sternum and clavicle as its fixed base.

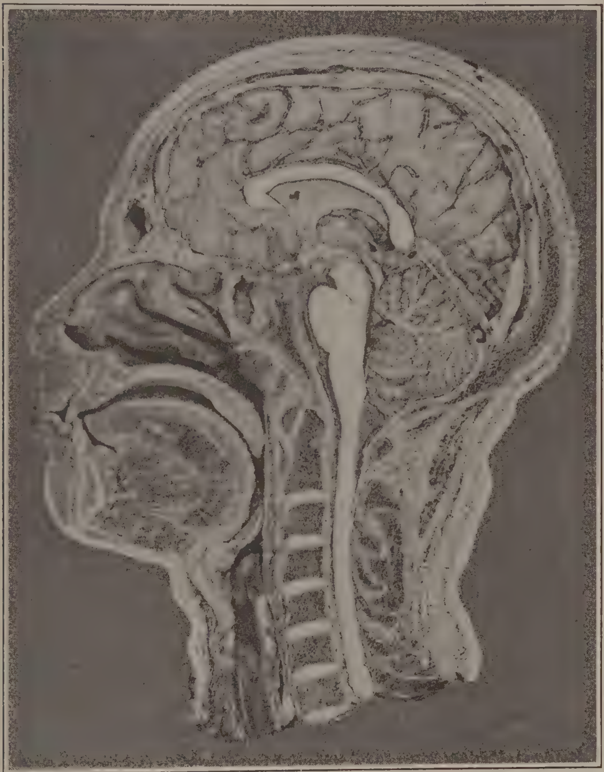

FIG. 10.—Median sagittal section of head, showing relation of structures in oral cavity when the mouth is closed. (Cryer.)

Under ordinary conditions when the mouth is closed (Fig. 10), the muscles are in repose and there is an absence of any active contraction on their part. The mandible is maintained in position partly by the tonicity of the levators, their length, however, in an ordinary state being too great to keep the jaws in contact. This is assisted by the influence of a certain negative intra-oral air-pressure amounting to about 2 to 4 mm. of mercury (Donders) which "is formed by the contraction of the muscles of the tongue and by the sinking of the mandible. The closed space arises from the closure of the lips, and the placing of the soft palate upon the root of the tongue."[1] The teeth are usually in contact at some point, the tongue nearly fills the cavity of the mouth, the lips and the cheeks are closely applied to the teeth and alveolar mucosa. This position is commonly termed "the resting bite." In it the teeth do not fit tightly together, the cusps not being closely received into their corresponding depressions, the condyles are distally placed in their fossæ, and the levators exhibit only ordinary tone.

If the levator muscles are contracted slightly, the jaw is drawn upward and backward to a position where the cusps and depressions of the teeth do correspond and we have a more closely fitting occlusion. At the same time the condyles are occupying their most distal position in the fossæ and we have what is called "the position of occlusion."

If the levators are still further contracted there is no closer fitting together of the teeth, but they are forced very slightly up into their sockets, a movement permitted by the elasticity of the pericementum, while at the same time the interarticular cartilage and other soft tissues intervening at the joint are likewise compressed slightly. It is the latitude of movement between the position of occlusion and this position which reduces the shock of the impact of the mandible during mastication.

THE MOVEMENTS OF THE MANDIBLE.

Because of the fact that it has two articulations, the movements of the lower jaw are so complex that it will be best for our purposes to describe the simple movements, and then to see how they may be combined to produce the more complicated ones. Therefore those will be first discussed in which the symphysis of the jaw is moved in the sagittal plane of the body, or in other words, movements which are bilaterally symmetrical.

Depression.—This is produced by the weight of the jaw and by the action of the mylo-hyoid, genio-hyoid, anterior belly of digastric, and the platysma myoides muscles, which serve to depress the forward end of the jaw, and by the action of the external pterygoid muscles which pull the heads of the condyles downward and forward. The jaw rotates about a horizontal axis passing through the condyles which at the same time are being moved downward and forward. Sliding is thus combined with rotation through the whole movement of depression of the mandible (Fig. 11).

The forward movement of the condyle is rendered necessary by the attachment of the external lateral ligament, which is so located as to compel a forward movement of the condyle when force tending to displace the jaw downward is applied at its anterior portion. It is also produced by the contraction of the external pterygoid muscle which pulls forward the condyle and the cartilage which surmounts it. Man's erect posture and the forward projection of the larynx necessitate this. The path which the condyle pursues, downward and forward, in this movement is dependent upon the shape of the glenoid fossa. Walker[1] found it to make "an angle ranging from 25 to 45 degrees to the line or plane of occlusion, being from 30 to 50 degrees to the facial line," the average of the former being 35 degrees, but states that it varies very much even on the two sides of the same individual.

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[1] Herbst, E.: Deutsch. Zahnarztl. Wchnschr.

In the extreme position of depression of which the jaw is capable the condyle is in the lowest and most anterior position which it ever assumes. While "the mandible describes approximately the arc of a circle" in this movement, "no portion of the actual path is coincident with the arc of a circle described from, as its center, any position ever attained by the condyle."[2] The radius of the circle described by the morsal edges of the lower incisor teeth may vary from 4½ inches in length to 7 or 8 inches, the center being therefore usually behind the condyle.[3] The center is generally from 1 to 1½ inches below the level of the condyle.

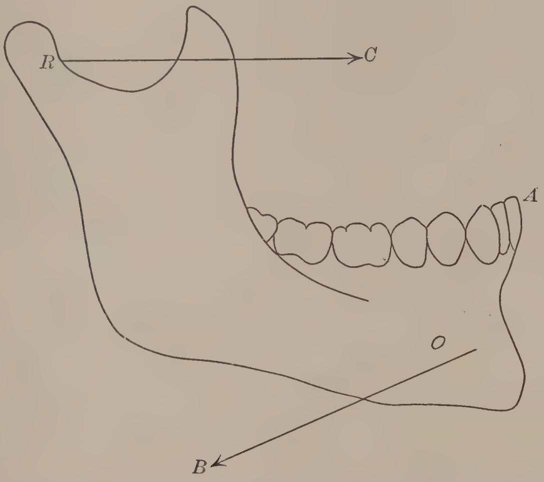

FIG. 11.—Diagram illustrating the direction of operation of the muscles in depressing the mandible. *R O*, line of traction of external pterygoid muscles; *O B*, line of traction of mylo-hyoid, genio-hyoid and digastric muscles. (After Constant.)

Elevation.—The simplest form which this movement may take is that which is the reverse of the one just described, the jaw pursuing the movement of depression in reverse order. The temporal, masseter, and internal pterygoid contract, serving to rotate the jaw about a horizontal axis passing through the condyles. The shape of the glenoid fossæ being such as to guide the condyles backward, they recede, the posterior elastic fibers of the capsule likewise carrying the cartilage back. In moving from the position of extreme depression, the contraction of the levators produces rotation about the condyles, the temporal muscle being most advantageously situated for this action. The stylomaxillary ligaments, from their point of attachment, serve in the beginning to cause a distal movement of the condyles as rotation takes place. As elevation proceeds, this is contributed to by the external lateral ligaments and by the posterior fibers of the capsular ligament, while the upward inclination of the fossæ serves to guide the condyles upward and backward. For the jaw to pursue this path there must be full and complete relaxation of the external pterygoids, or the condyles will not move backward. After a certain point has been reached, these muscles have the power of fixing the condyles on their return path to the distal part of the glenoid fossæ, and then elevation consists in a rotation of the jaw about them in this position. If they do not relax, or if there is contraction of the protrusor fibers of some of the levator muscles, the elevation may have combined with it some of the movement of protrusion. Tomes and Dolamore[1] found that in normal closure of the jaw the path of its anterior end is almost constantly anterior to that of opening. It is possible for the mandible to move from its most depressed position to that of occlusion, to that of extreme protrusion, or to any position between these, by paths which depend in their character upon the proportion of protrusive movement combined with the elevation.

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[1] Dental Cosmos, vol. **38**, p. 34.

[2] Tomes and Dolamore: Trans. Odontol. Soc. Great Britain, 1900, p. 167.

[3] Loc. cit.

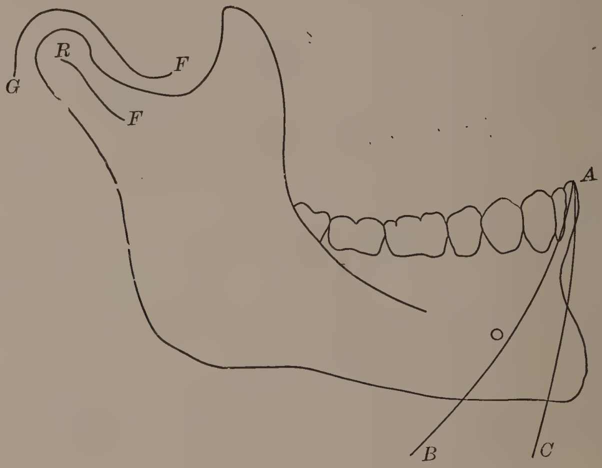

Fig. 12.—Diagram illustrating the path pursued by the mandible in depression. *G F*, glenoid fossa; *R*, center of condyle; *R F*, path pursued by center of condyle; *A*, cutting edge of lower central incisors; *A B*, path which would be described by *A* if the mandible rotated about *R* and condyle remained in fossa; *A C*, actual path pursued by *A* in depression of the mandible in which rotation and sliding are combined; *A′*, approximate geometric center of circular path *A C* actually pursued by the point *A*.

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[1] Loc. cit.

Protrusion.—When the natural teeth are in occlusion the jaw cannot be carried forward until it has been slightly depressed to disengage the cusps, or unless during protrusion the cusps of the lower teeth slide downward and forward in the fossæ of the upper teeth into which they fit, thus serving to slightly depress the mandible during this movement. In an edentulous mouth, however, this does not obtain. The jaw is moved forward by the action of the external pterygoids contracting simultaneously, assisted by the external fibers of the masseter and the anterior fibers of the temporal and some fibers of the internal pterygoid (Constant). The external pterygoid also pulls forward the interarticular cartilage, this movement, however, being also due to the intimacy of its attachment to the condyle by means of the capsular ligament. The condyles move downward and forward, thus depressing the distal portion of the lower jaw on the average about $\frac{1}{8}$ inch, a fact brought out by Balkwill[1] and later by Walker[2] and several investigators since him, the amount of the depression being determined by the inclination of the glenoid fossa and differing vastly in different individuals. In the most forward position assumed by the jaw in protrusion, the condyle is nearly upon the eminentia articularis. This, however, is not as far forward as in the position of greatest depression, for in addition to the joint ligaments proper, the stylo-maxillary, and other tissues attached to the back of the ramus are put on the stretch and prevent the forward movement of the condyle, unless it is rotated forward as occurs in depression of the mandible.

Retraction.—This is the reverse of the movement of protrusion, and the jaw may be brought back along the same path which it pursued in the forward movement. This is produced by the contraction of the posterior fibers of the temporal, the internal portion of the masseter, the digastric, the genio-hyoid and mylo-hyoid muscles. The condyle is carried backward and upward, the cartilage accompanying it. There may be combined with this various amounts of depression, as for instance, the jaw may move from its most protruded position back to that of occlusion, or to its most depressed position, or to any point or along any path intervening between the two. In moving from the most protruded to the most depressed position, the stylo-maxillary and the posterior fibers of the capsular ligament being on the stretch, cause the condyle to be moved forward and downward.

Combinations of these two kinds of movements may occur in various amounts. Thus far we have considered the movements which the lower jaw may make by simultaneous and equalized contraction of the muscles of both sides.

Lateral Movements.—The lateral excursions of the mandible are made possible by the sliding character of the temporo-mandibular joint and the fact that protrusion of the condyles may occur independently on either side. The external pterygoid muscle and the pterygo-meniscus do not operate in a plane identical with or parallel to that in which the condyle moves in its forward excursion. Its action is to pull the condyle inward as well as forward and it is only by the simultaneous contraction of both that the jaw is bodily protruded (Fig. 13). Acting singly, therefore, when the condyle on the opposite side is held in the fossa, its influence is to draw the condyle inward, forward and downward over the inclined floor of the fossa causing a rotation of the mandible about an approximately vertical axis passing through the opposite condyle. In this movement the path of the condyle (Fig. 14) is approximately in the arc of a circle upon the floor of the fossa, and it may be carried no farther forward, if, indeed, as far as in the movement of protrusion. The simplest form of the return movement is for the condyle to pursue the same path back to its distal position in the fossa. When the jaw is carried to the other side in its lateral excursion, the opposite condyle in turn is pulled downward and forward, and the jaw rotates about the other.

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[1] Trans. Odontol. Soc. of Great Britain, vol. **5**, p. 133.

[2] Dental Cosmos, vol. **38**, p. 34.

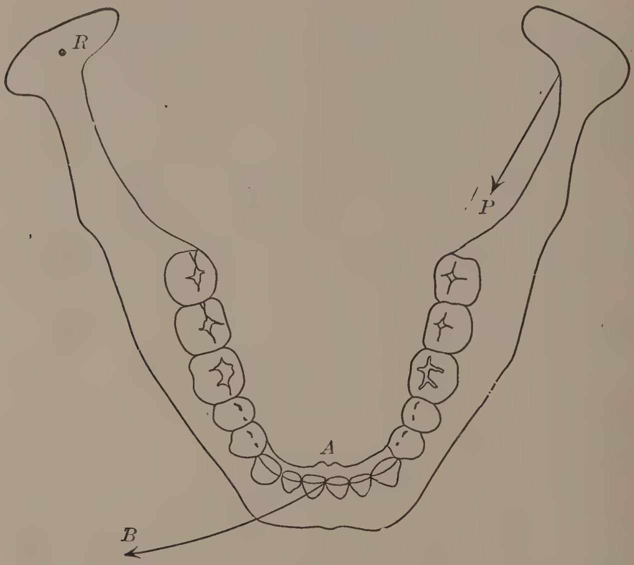

FIG. 13.—Diagram illustrating action of external pterygoid muscle. *R*, stationary center of rotation in right condyle; *P*, line of action of left pterygoid; *A B*, path pursued by point *A* on contraction of left external pterygoid.

Walker observed that in the lateral excursion the actual rotation point was not always situated in the condyle, but that it was sometimes internal to and sometimes external to the condyle.

Mr. Norman G. Bennett[1] has called attention to the fact that at times and in certain mouths the entire mandible is carried to the side to which the lateral excursion occurs, a movement due to the relaxation or laxity of the joint ligaments, to the shape of the condyle and fossa, and to the lateral pull of the muscles. This lateral movement is small in amount and is independent of the radial swing in the lateral excursion. Gysi and various others have confirmed Bennett's observations.

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[1] A Contribution to the Study of the Movements of the Mandible, Proc. Roy. Soc. Med., Odontol. Sec., April, 1908.

Lateral movement may be combined with that of depression of the jaw as above described. In this event the lateral movement simply seems to make an alteration in the position of the horizontal axis about which the rotation element of the movement of depression takes place. The greater the forward pull on one condyle as related to the other, and hence the greater the lateral movement, the less depression may be combined with it, and as the depression increases the lateral movement must of necessity decrease. We have seen that in the most depressed position of the lower jaw both condyles are in the most forward and downward position near the eminentiæ articulares, from which position it is impossible to produce any lateral movement. Lateral movement and depression in any combination of these two are always, therefore, inversely related to each other.

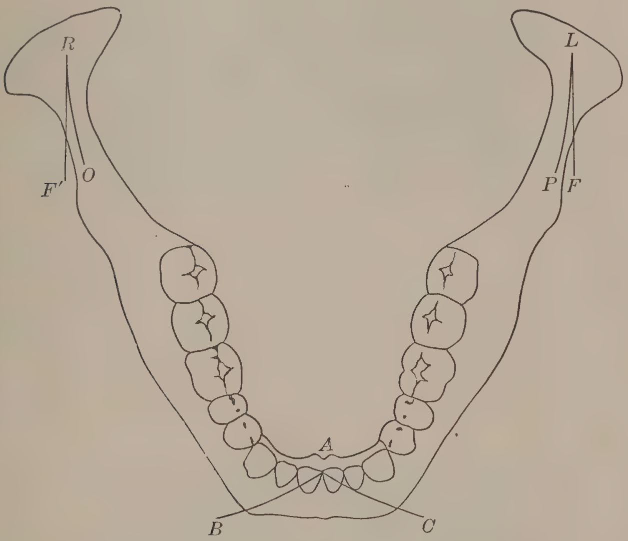

FIG. 14.—Diagram illustrating forward and lateral excursions of the mandible. *R O*, path pursued by right condyle when jaw is rotated to the left about *L; L P*, path pursued by left condyle when jaw is rotated to the right about *R; RF′* and *LF*, paths pursued by right and left condyles respectively when mandible is carried bodily forward.

Lateral movement may also be combined with forward translation of the jaw, its rotation about a vertical axis then occurring at the place in which the condyle through which it passes is fixed in the glenoid fossa. This means simply that the condyle, about which rotation in the lateral movement has occurred, is not in its distal position in the fossa, but has been carried forward along with its fellow of the opposite side. It becomes evident that these movements are similarly inversely related, for the farther forward one condyle is carried, the less distance remains to the other for rotation about it. It may be said that the condyle in the most distal position—the one about which rotation takes place—always occupies a point in the path pursued in their dual forward movement. The return movements partake of the character of their constituents as may be seen above.

The various combinations of depression with forward translation, and the addition to these of changes in the direction of the horizontal axis of rotation passing through the condyles, which their independent movement forward produces, gives to the mandible a range of movement beyond that of any other joint in the body. Within the limitation imposed by the joint ligaments, and when the teeth are not in contact, the position of the jaw at any one time is determined by the balance established between the opposed pairs of muscles which produce its movements. When the teeth touch, however, they become a factor in determining the position of the forward end of the mandible. It is evident, therefore, that so long as they are in contact, their form and position has much to do with the position of the jaw and its paths of movement. The slight laxity of the ligaments, and the compressibility of the tissues intervening between the bones and the varying pull of the muscles allow some slight latitude in the paths pursued.

THE TEETH.

The jaws are equipped with the teeth in two opposed series which serve as specialized organs in the mechanical subdivision of the food. As the armament for the fixed and movable elements of the masticating apparatus, they are brought into functional relation by the muscles operating the mandible. In the typical or ideal denture they are of such form and arrangement as to best subserve the interests of the masticatory function.

In order to comprehend the various relations which the teeth have during the functional activity of the mechanism, and to see how its ends are best subserved by their form and arrangement, it will first be necessary to study the teeth of each jaw separately, particularly with regard to their occlusal surfaces. Then, as the position of occlusion is the ultimate one toward which the mandible tends in all its masticatory efforts, it will be necessary to study the relative position of these morsal surfaces when the teeth are in occlusion, and then their relation during the masticatory movements of the mandible may be understood. Inasmuch as we are considering them as mechanical appliances solely, no attempt will be made to give their anatomy except as it concerns this matter.

As viewed from their occlusal surfaces, the teeth (Figs. 15 and 16) are seen to be arranged in the jaws in two arch-shaped series of sixteen teeth each. The outline of the arch in general is that of a parabola. While it varies considerably within the limits of the normal, as will be seen in Chapter VII, its form is related to several other variable factors to be considered conjointly later in this chapter, and variations in this particular may occur which are not at the expense of the mechanical effectiveness of the apparatus. The arch outline is determined by the position of the individual teeth, but is affected by their size—both actual and relative—and their shape. The general proportion existing between the size and form of the individual teeth in either the upper or the lower series is fairly constant. Slight variations occur, but as they are more important from a cosmetic than from a functional standpoint, they will not be considered here. The proportion between

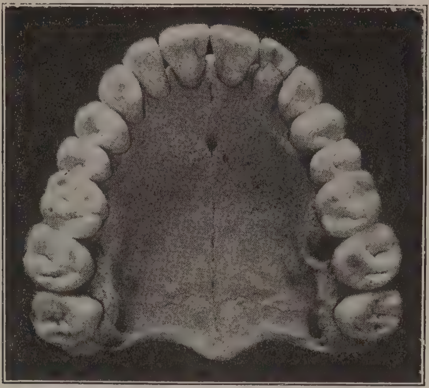

Fig. 15.—Occlusal surfaces of the upper teeth.

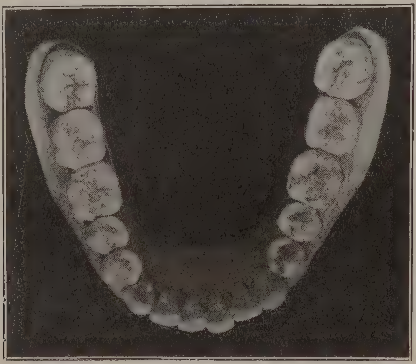

Fig. 16.—Occlusal surfaces of the lower teeth.

the corresponding teeth of the upper and lower series of any denture is also practically constant, the individual teeth in one jaw being usually associated with those of corresponding size and shape in the other. This will be seen more clearly when their occlusion is discussed.

The outlines of the upper and lower arches correspond in shape in order that the teeth may be opposed throughout their series, except that the upper is slightly larger and overhangs the lower externally. This difference in size is necessary in order that the fixed base shall present a sufficiently large surface for contact during the excursions of the movable arm and it is extended in the direction of these movements. This is due to the greater size of the upper teeth and the greater segmental form of the arch; both the overhanging and difference in size decrease from the median line backward.

The teeth of each arch (Figs. 15 and 16) are seen to present an unbroken series of occlusal surfaces extending from the terminal molar on one side to that on the other. Besides giving greater surface area for masticatory purposes, this approximal contact provides a mutual support for the teeth which is of great value. When the character of man's food is remembered, it will be seen that this provision is also of some importance for the protection against injury of the soft tissues of the interproximal space.

The teeth are divided into four classes anatomically, and their functions as mechanical instruments more or less correspond to this division. As viewed from their occlusal surfaces (Figs. 15 and 16), it will be noted they are well-shaped for their several offices. The incisors are designed to cut off definitely sized masses of food, and their morsal surface is in the form of a broad blade, the labial and lingual surfaces meeting at an angle at the incisal edge. The canines in the lower animals serve largely for prehension—to pierce and hold the more resistant food, and among the carnivora to guide the lower jaw into place. In man these functions are largely rudimentary, the tooth being intermediate in function between the incisors and bicuspids. It has a double blade, ending in a well-defined point. The bicuspids, as their name implies, have two cusps, and are intermediate between the canines and molars. Williams asserts that their office is "to catch, hold and crack brittle foods, and to pierce between fibers which have been placed along them and are being held by the sliding articulation of cuspids and molars." While their function is largely to crush and press the food, they participate in trituration, which is the characteristic office of the molars. The greater sharpness of their cusps fits them more for piercing than for grinding. The molars are the grinding teeth proper, for which their tuberculated surfaces are well designed. The cusps alternate with fossæ and grooves, and are joined by ridges which afford a surface most effective for trituration as will be seen later.

It will be observed of the molar and bicuspid series of cusps and depressions of each jaw, that as they are higher and larger anteriorly, they are smaller and shorter as the distal end is approached, so also there is a diminution in the distance between them both mesio-distally and bucco-lingually.

The Occlusion of the Teeth.—When the ideal or typical denture is viewed in occlusion (Fig. 17), it will be seen that there is a definite mutual relation of the occlusal surfaces of the teeth. It will be observed that there are two different types of occlusion—first, that corresponding to the incisiors and canines, in which the morsal edges do not meet end to end, but those of the lower teeth rest upon the lingual surfaces of the upper; and second, that corresponding to the molar and bicuspid teeth, where considered collectively their cusps are either received into fossæ or depressions in the occlusal surface of the opposing series, or overlap the buccal or lingual surface of their opponents. It is notable that with the exception of the lower central incisors and the upper third molars, each tooth is opposed by portions of two others. This provision serves to dissipate the force of impact in occlusion, and tends to preserve the integrity of the denture; for with this arrangement the loss of a tooth in one arch does not mean the loss of a tooth in the other through lack of antagonism.

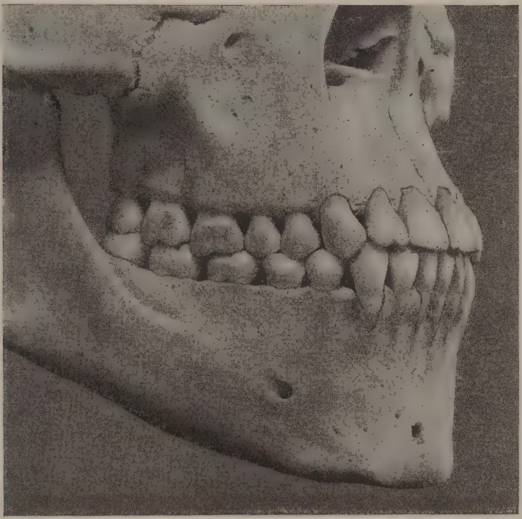

Fig. 17.—Upper and lower teeth in occlusion. (From photograph of specimen in the Wistar Institute of Anatomy.)

The Occlusion of the Incisors.—The typical occlusion for the incisors is shown in Fig. 18, in which it will be seen that the upper incisors overhang the lower for about one-third their labial surfaces. This relation is spoken of as the normal overbite of the incisor teeth and obtains in a large percentage of cases. The angle formed by the long axes of the upper and lower incisors differs much in individuals, and the contact between the two varies in consequence. In some the angle is so obtuse that there is considerable contact between the labial surface of the lower and the lingual surface of the upper incisors. The size of the arch of the upper may be so great that the lower teeth are not in contact with the upper in the position of occlusion, only coming in contact when the lower jaw is protruded in incision. The so-called "edge-to-edge" bite of the incisors, which is seen in those cases in which the overbite has been short and the teeth have worn, or have been originally erupted in this position (Fig. 19, *B*), is within the range of the normal but is a less effective mechanical arrangement for incision.

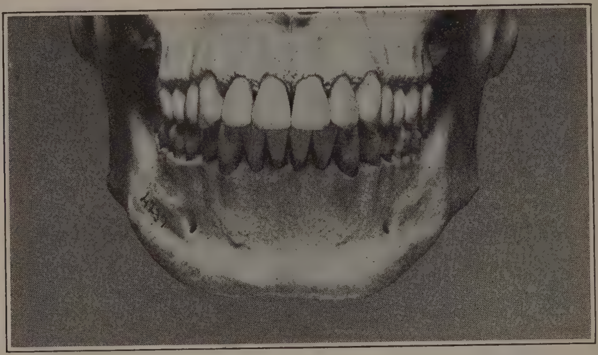

Fig. 18.—Occlusion of the incisor teeth. (From photograph of specimen No. 4237, Wistar Institute of Anatomy.)

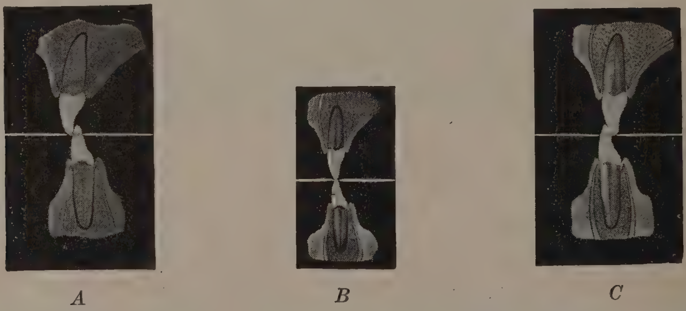

Fig. 19.—Occlusion of the incisor teeth. *A*, normal overbite; *B*, edge-to-edge bite; *C*, upper incisors distal to lower. (Grevers.)

The condition presented by Fig. 19, *C*, in which the upper incisors occlude lingually to the lower is less effective still, because the lower jaw cannot move backward to bring the teeth into contact.

In a typical denture Balkwill[1] has pointed out with regard to the scissors-like action of the front teeth. that as they are wedge-shaped, he "expected to find the angle of the wedge equally divided by the circle of motion, which would give the greatest dividing power," but this is not the case. The angle of the wedge points more outward in the upper and inward in the lower, and he reminds us that in closing the teeth, there is a backward as well as an upward motion. Burchard has pointed out the effect of this motion upon the direction of the impact of the teeth during closure of the jaw; that unless there was a backward movement at the same time, the effect would be to drive the upper incisors forward.

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[1] Trans. Odontol. Soc. Great Britain, vol. 5, p. 133.

The Oçclusion of the Bicuspids and Molars.—The bicuspids and molars on each side viewed collectively (Fig. 22), may be considered as consisting of a series of cones or cusps alternating with fossæ or depressions, and so fitted together when the teeth are in occlusion that the fossæ receive cusps of the opposing teeth. The inner line of cusps of the upper are received into the fossæ between the outer and inner cusps of the lower (Fig. 21), the outer line of cusps of the lower being correspondingly received into fossæ in the upper (Fig. 20). Thus the lingual cusp of the first upper bicuspid (Fig. 21) is received, between the buccal and lingual cusps of the lower bicuspids, the point of the cusp corresponding to the line between the mesial marginal ridge of the second and distal marginal ridge of the first. Similarly, the lingual cusp of the second upper bicuspid is received at the line of contact between the marginal ridges of the second lower bicuspid and first molar. The mesio-lingual cusp of the first upper molar fits into the central fossa of the first lower molar, while the disto-lingual cusp occupies a position in relation with the adjoining marginal ridges of the first and second lower molar teeth, *i. e.*, in the depression between the disto-lingual and buccal of the first lower molar and mesio-lingual and mesio-buccal of the second lower molar. The second upper molar occludes similarly with the lower second and third molars, while the third upper molar varies in this respect as it varies in form. The large lingual cusp, usually found on this tooth, however, normally occupies the central fossa in the third lower molar.

The buccal cusps of the lower are received into the fossæ and depressions of the upper teeth as follows (Fig. 20): The buccal cusp of the first lower bicuspid is in relation with the distal marginal ridge of the canine and the mesial marginal ridge of the first bicuspid (Fig. 22). This is less like a cup-shaped depression than any which succeed in this description. The second bicuspid has its buccal cusp received in the depression between the buccal and lingual cusps of both upper bicuspids, its point being in definite relation with their adjacent marginal ridges. The mesio-buccal cusp of the first lower molar rests in relation with the adjoinging marginal ridges of the first upper molar and the second bicuspid, while the large buccal cusp is received in the central fossa of the first upper molar. The disto-buccal cusp of the first lower molar, which is present in 50 per cent of cases, is usually so distally located that it shares with the mesio-buccal cusp of the second lower molar the

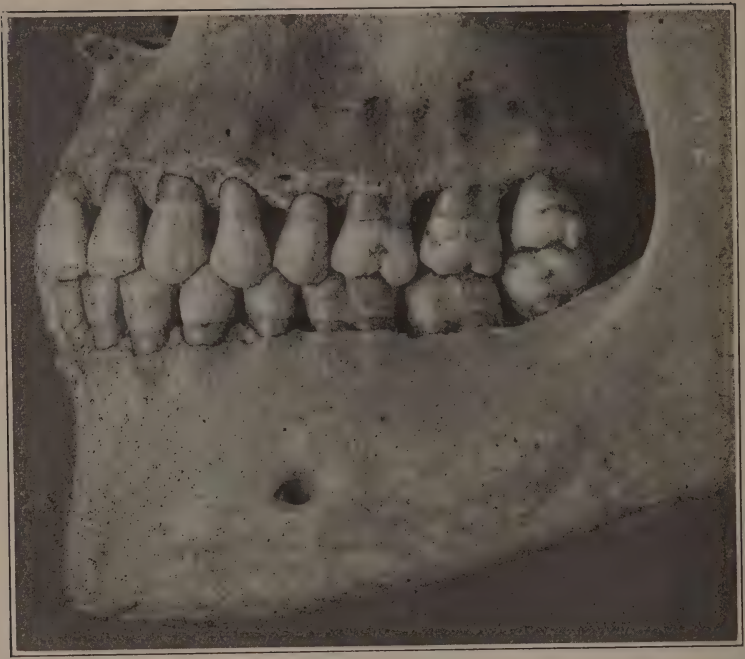

FIG. 20.—Occlusion of the molar and bicuspid teeth, external view. (From photograph of specimen in possession of Dr. F. A. Peeso.)

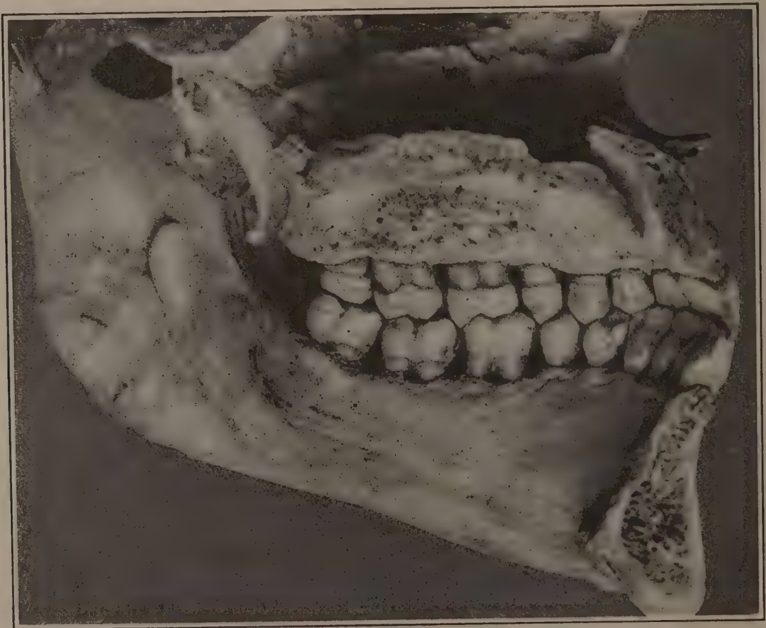

FIG. 21.—Occlusion of the molar and bicuspid teeth, internal view. (From photograph of specimen in possession of Dr. F. A. Peeso. Same specimen as Fig. 20.)

space between the cusps of the first and second upper molars and is in contact with their adjacent marginal ridges; or it is forced to the lingual to be lost in the distal marginal ridge. The mesio-buccal cusp of the second lower molar has just been located, while the remainder of the tooth is similarly related to the upper first and second molars as the first molar is to its two antagonists. The third lower molar varies so in form that it is difficult to say what is its typical occlusion. The two types most commonly seen (Broomell)[1] are those with four or five cusps respectively, the occlusion being similar to the molars already described with regard to the mesio-buccal and buccal cusps in either case, while where the fifth cusp is present, it occludes simply with the distal portion of the upper molar.

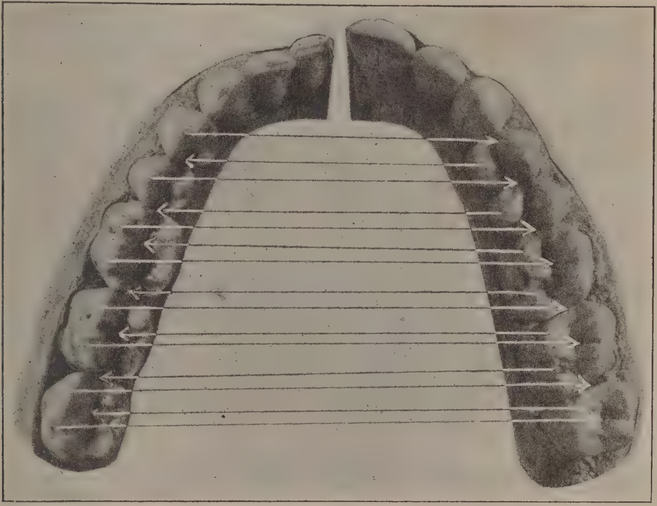

Fig. 22.—Occlusion of the molar and bicuspid teeth, occlusal view. Lines are drawn from the lingual cusps of the upper teeth and buccal cusps of the lower to the corresponding depressions into which they fit. (From photograph of specimen in possession of Dr. F. A. Peeso. Same as Figs. 20 and 21.)

The buccal cusps of the upper molars and bicuspids are sharper than the corresponding lingual cusps (Fig. 23). They are related to the lower teeth as follows (Fig. 20): That of the first bicuspid is received in the groove between the buccal cusps of the lower bicuspids and to the buccal side of the teeth. That of the second corresponds to the space between the buccal cusp of the second lower bicuspid and mesio-buccal of the first lower molar. The mesio-buccal of the first upper molar is received in the buccal groove of the first lower molar, the disto-buccal cusp occupying the disto-buccal groove, where the lower molar has five cusps, or the space between the second molar and the first, where it has four. The buccal cusps of the second upper molar occlude so similarly to those of the first that they require no mention, while the two buccal cusps of the third likewise similarly occlude, except where the lower molar has no disto-buccal cusp, when only its last cusp is in relation with the distal surface of the lower tooth.

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[1] Anatomy and Histology of the Mouth and Teeth.

As to the lingual cusps of the lower teeth (Fig. 21), they are in general smaller and more pointed (Fig. 23) than the buccal. A marked exception exists in the case of the first lower bicuspid whose lingual cusp is frequently so rudimentary as to be represented only by a ridge of enamel; the second is sometimes similarly formed. Bonwill[1] has pointed out the lack of function of this cusp of the first bicuspid, which fact will be seen more clearly when the functions of the teeth are described. When present, this cusp is in relation only with the mesial slant of the lingual cusp of the first upper bicuspid. The lingual cusp of the second is lingually placed to the space between the lingual cusps of the two upper bicuspids, while the mesio-lingual cusp of the first lower molar is similarly placed bewteen the first molar and second bicuspid. The disto-lingual cusp corresponds in position with the lingual groove of the first upper molar. The lingual cusps of the second molar are similarly related to the first and second upper molars, and this is likewise frequently true for the third lower molar, with the exception of its disto-lingual cusp, which, having no groove with which to be in relation, touches only the distal incline of the single lingual cusp of the upper third molar.

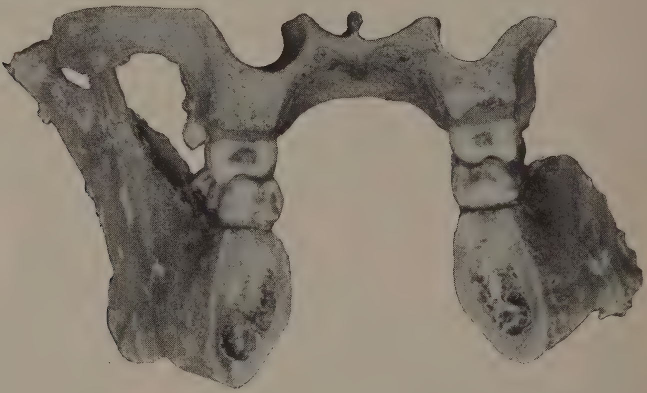

Fig. 23.—Section through upper and lower teeth in occlusion, showing relative height and sharpness of buccal and lingual cusps. (Cryer.)

It will be noted that the cusps received into fossæ are the more rounded, and that the cusps which overlap are the sharper and the smaller (Fig. 23).

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[1] American System of Dentistry, vol. 2, p. 495.

In the upper jaw it is noted that the fossæ are separated antero-posteriorly or mesio-distally by the transverse ridges of the bicuspids and by the mesial marginal and oblique ridges of the molars. These ridges are received by the grooves separating the buccal cusps of the lower teeth. The lower fossæ and depressions which receive the lingual cusps of the upper series are similarly separated, and these ridges are received into the grooves separating the lingual cusps of the upper teeth (Fig. 22). It is evident that in order to move the jaw in any direction it must be depressed to disengage the cusps from these fossæ.

The actual height of the cusps and the corresponding depth of the fossæ vary greatly in different individuals. It may be mentioned here, however, that this variable factor is one of that related group which will be considered later in this chapter. Bonwill[1] has stated that there is an almost constant relation between the overbite of the incisors and the length of the cusps of the bicuspid and molar teeth (Fig. 24). Where the overbite is considerable, the molars and bicuspids will usually be found to possess high cusps, the overhanging of the buccal cusps of the upper being an index of their length, while short cusps are associated with a small amount of overbite. In either event the cusps grow proportinally shorter from before backward. While this proportion is fairly constant for typical dentures, many instances of a departure from it are found. A denture conforming closely to the description of the typical denture in every particular except this, is shown in Fig. 25.

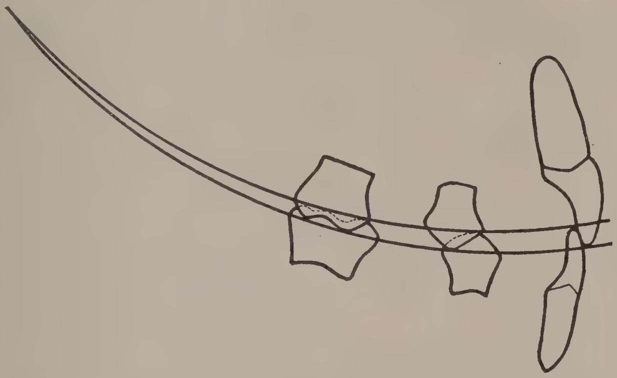

FIG. 24.—Diagram showing typical proportion between cusp length and overbite. Modified from Bonwill.

The canine tooth occupies a position between the incisors and the masticating teeth and hence is intermediate in the character of its occlusion. Where from the shape of the arch it continues the line of the molars and bicuspids, it partakes more of their type of occlusion, and its overbite corresponds to the overlapping of the molar and bicuspid cusps and is proportioned to them in this regard. When its position is more in the line of the incisors, it partakes of their type of occlusion, its overbite corresponding with theirs, while if it is intermediate in position, it participates in the character of both types of occlusion.

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[1] American System of Dentistry, vol. 2, p. 488.

We next come to discuss some peculiarities of the occlusion of the bicuspid and molar teeth, which are so closely related to the manner of movement of the mandible and have so important a bearing upon the efficiency of these teeth as masticatory organs, that it will be necessary to bear in mind the movements of which the lower jaw is capable in order to understand the functional significance of these characteristics.

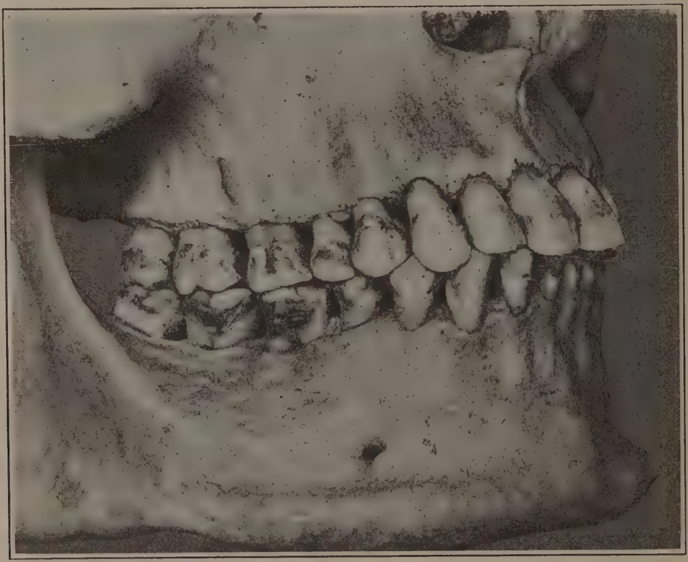

Fig. 25.—Denture typical in other respects exhibiting disproportion between cusp length and overbite. It will be noted that the cusps of the first molar are much worn, as this is the oldest tooth in the mouth. (From photograph of specimen from Dr. Cryer's collection.)

If a curved line be drawn touching the summits of the buccal cusps of the lower teeth from canine to third molar, it will more or less accurately correspond to the arc of a circle with its convexity downward (Fig. 26). The lower lingual cusps will be found to occupy a similar line and both series of cusps of the upper teeth correspond also to the arc of a circle. This condition is to be attributed to differences in the level of the teeth and in the direction of their long axes as they are placed in the alveolar process. The long axes of the upper teeth anterior to the second bicuspid are inclined toward the median line of the denture, that of the second bicuspid being practically vertical, while the teeth distal to it are placed at a higher level in the bone and have their long axes increasingly inclined away from the median line. In the lower jaw a corresponding condition is found, successive cusps of the series being placed at higher levels in each direction from the mesial cusps of the first molar which marks the lowest portion of the curve (Fig. 26). This is frequently spoken of as the "compensating curve" of the molars and bicuspids, and also as the "Curve of Spee," by whom it is described.[1] This curve varies considerably in different individuals. In its most ideal form, if continued in a projection of the jaw upon the vertical sagittal plane, it touches the anterior face of the articular surface of the condyle (Fig. 27). It more frequently passes posterior to this than anterior. In typical dentures its form has a definite relation to two of their characteristics which have already been mentioned, viz: the length of the cusps of the teeth, and the path which the condyles pursue in the forward excursion of the jaw. The relation existing between the curve and these two factors may be stated thus: The longer the cusps of the molars and bicuspids, the shorter will be the radius of this curve, and the shorter the cusps, the longer will be its radius; also, the greater the inclination of the glenoid fossæ and hence the greater the angle between the path of the condyles and the horizontal, the less will be the radius of this curve, while the more nearly horizontal is the path of the condyles in their forward movement, the longer will be the radius of the compensating curve. To understand the bearing of this feature of the occlusal surfaces of the bicuspid and molar teeth upon the forward excursion of the jaw, let us see what takes place if this movement occurs and the lower teeth maintain contact with the upper, simply sliding forward over their occlusal surfaces. It must be evident that the path of the jaw would be determined during

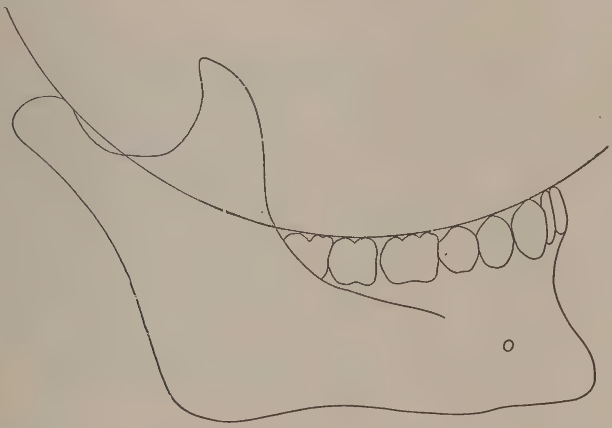

FIG. 26.—Diagram illustrating the *compensating curve* or the "curve of Spee."

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[1] v. Spee, F. Graf: Die Verschiebungsbahn des Unterkiefors am Schädel, Arch. f. Anat. u. Physiol., 1890.

this movement by the condyles and fossæ posteriorly and by the teeth anteriorly. The object which this arrangement serves is that all of the bicuspid and molar teeth shall be in contact within a certain range of the forward and backward movement of the mandible. It likewise provides that when the mandible is elevated into contact with the upper jaw not too far forward of the position of occlusion, the lower teeth may simultaneously strike their opponents and be able to preserve a sliding contact with them in the retraction of the jaw to the position of occlusion.

We have already seen that the position of the lower jaw at any time when the teeth are in contact is determined anteriorly by this contact of the teeth, and posteriorly by the glenoid fossæ upon which the condyles rest. Its path, therefore, during a sliding contact of the teeth, would be determined anteriorly by the teeth and posteriorly by the fossæ over which the condyles move. That there must be a correspondence between these is evident. In order to understand how it is possible for this sliding contact of the teeth to take place, and for sake of simplicity in description, let us suppose that the opposed surfaces are smooth instead of being broken up into cusps and fossæ (Fig. 27).

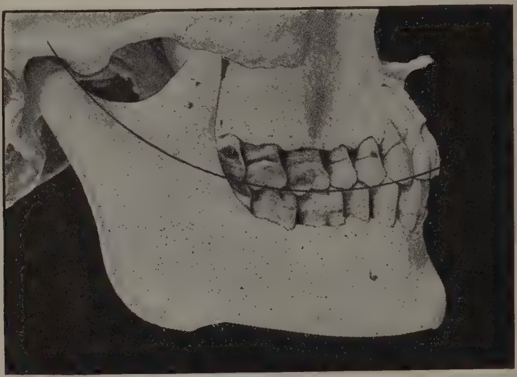

Fig. 27.—The "curve of Spee." Line passing through anterior face of condyle. (From a photograph of a specimen in the Wistar Institute of Anatomy.)

In order that the lower teeth may slide upon the upper and the contact be interrupted at no point, the sliding surfaces must be either perfectly flat or represent a curved plane, a section of which would be the arc of a circle. These are the only two kinds of surfaces between which a sliding contact could take place. In the former case the sliding body moves in a straight line, in the latter in the arc of a circle. That the condyle must move in a path harmonious with that pursued by the teeth of the lower jaw becomes evident when it is remembered that the jaw moves as a whole. Where the sliding surfaces are planes and the jaw moves in a straight line, the condyle moves in a line parallel to this or identical with it. When they correspond to the arc of a circle, the condyle moves also in the arc of a circle, its path concentric with or identical with it. If this did not occur the sliding contact between the teeth would be interrupted.

We find therefore that when the general line of the teeth is that of the arc of a circle, that portion of the fossa over which the condyle slides is likewise an arc which is either identical or concentric. And the more nearly the plane of the teeth approaches a straight line or an arc with an infinite radius, the more nearly straight is the floor of the fossa. These two associated and related characteristics vary therefore in individuals. With a well-defined curve of the molars and bicuspids, there must be a corresponding slant of the glenoid fossæ to permit the condyles to descend as the jaw sweeps round this curve, while where they are more nearly in a straight line and the jaw may move the more bodily forward, the fossæ do not incline downward so much but permit the condyles to go more horizontally forward.

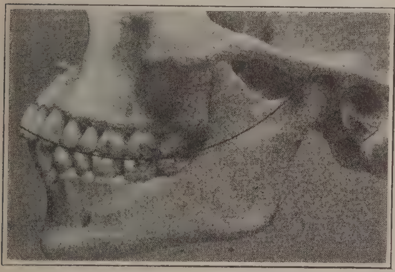

FIG. 28.—The "curve of Spee." Short cusps and long curve. Line passing through anterior face of condyle. (Specimen No. 4237, Wistar Institute of Anatomy.)

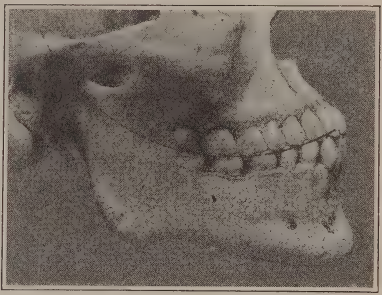

FIG. 29.—The "curve of Spee." Short cusps and long curve. Line passing distal to anterior face of condyle. (From photograph of specimen No. 800, Wistar Institute of Anatomy.)

The addition of cusps to the surfaces of the teeth complicates very much this sliding contact. In fact the surfaces do not slide as such, but the points of the cusps of the lower teeth glide upon the fossæ of the upper. We have already seen that from before backward the cusps get proportionately shorter and, of course, the fossæ into which they are received are proportionately shallower. As the mandible is moved forward these cusps have the effect of separating the jaws, or of rotating the mandible about a horizontal axis passing through the condyles. This is produced by the lower buccal cusps sliding upon the anterior walls of their fossæ, while the fossæ in the lower teeth containing the lingual cusps of the upper teeth slide upon them. This provision keeps the cusps in contact during the forward movement until the incisors come into action, and where the normal overbite exists, the lower centrals then slide down the lingual surface of the upper incisors and separate the distal teeth. Usually when the incisors are edge-to-edge, all the teeth distal to them are out of contact.

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From what has been said it will be seen that the buccal cusps of the lower teeth and the lingual cusps of the upper are the ones which it is most important should conform to the compensating curve, since they are in contact with the fossæ. One of the commonest variations from this typical arrangement which will be observed, is that in which the distal cusps of the upper molars are below the curve mentioned, the long axes of the teeth being almost vertical (Fig. 17). In such cases if the jaws are typical in other respects the mesio-buccal cusps will be found more or less worn down to conform to the general plan, the disto-buccal remaining unworn, because they occupy space between the lower teeth and not in their buccal grooves.

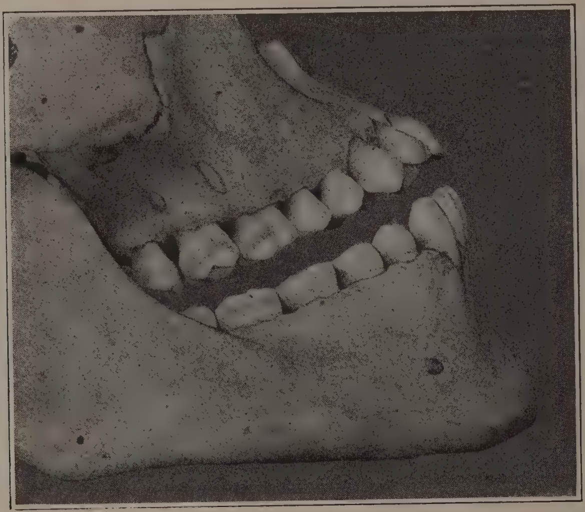

FIG. 30.—Upper and lower bicuspid and molar teeth, side view, showing relative height of buccal and lingual cusps of upper teeth. (From photograph of a specimen in the Wistar Institute of Anatomy.)

Another characteristic of the molar and bicuspid teeth may be observed in Figs. 30 and 31, in which it may be seen that their buccal and lingual cusps are not on the same level, the buccal cusps occupying a higher relative position as we proceed backward from the first bicuspid. In the upper jaw the lingual cusp of the first bicuspid is usually higher than the buccal, the cusps of the second bicuspid being either on the same level or the buccal being slightly higher (Fig. 30). The buccal cusps of the first molar are successively higher than the lingual, and this continues until we find those of the third molar relatively highest of all (Fig. 30). This condition obtains also in the lower jaw (Fig. 31). It is partly due to an actual anatomical difference in the height of the cusps as the tooth is viewed out of the mouth, and partly due to the increasing inclination of the long axes of the teeth in the alveolar process. This is another of the related factors subsequently to be considered and varies with the path of the condyle. That this condition provides for the contact of the cusps in the lateral excursion of the jaw has been well brought out by Walker[1] (Fig. 33). When the jaw is moved to one side with the teeth sliding in contact it rotates about a vertical axis passing through the condyle on that side, the opposite condyle moving inward, forward, and downward. On the side toward which the movement is taking place, the rounded buccal and the lingual cusps of the lower teeth slide upon and come in contact with the buccal and lingual cusps, respectively, of the upper teeth. On the opposite side the high buccal cusps of the lower teeth slide up and come in contact with the high lingual cusps of the upper teeth, which is rendered possible by the fact that the jaw is depressed on that side. If the condyle simply moved forward instead of downward as well, the buccal and lingual cusps might be of the same height and this same relation of the cusps would obtain, but as it moves downward the outer cusps have to be higher in order that there shall be compensation for the rotation of the jaw about a vertical axis passing through the stationary condyle.

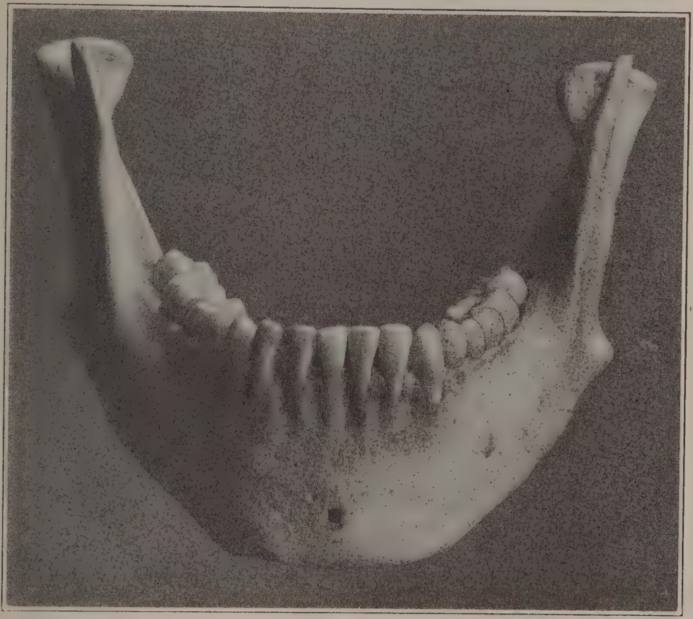

FIG. 31.—Lower bicuspid and molar teeth, front view, showing relative height of buccal and lingual cusps. Same mandible as Fig. 30. (From photograph of a specimen in the Wistar Institute of Anatomy.)

This provision serves to balance the masticating force and prevent overstrain when the jaws are in occlusion in the lateral position. It provides contact of the teeth on both sides to resist the strain exerted by the pairs of levators which have simultaneously contracted. With artificial dentures this condition may be imitated to advantage for a purpose to be discussed in a later chapter. Thus it will be seen that, in the movement of the jaw forward or from side to side, there is a series of cones which may be applied to the food, the series of cones or depressions so alternating and being so arranged in each jaw that within a certain range of movement the whole series of cones may be in contact with opposing surfaces of some sort. The immense functional value of this is obvious, and it is also apparent that this provision tends toward preventing overstrain and undue shock upon the denture.

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[1] Dental Cosmos, vol. **39**, p. 789.

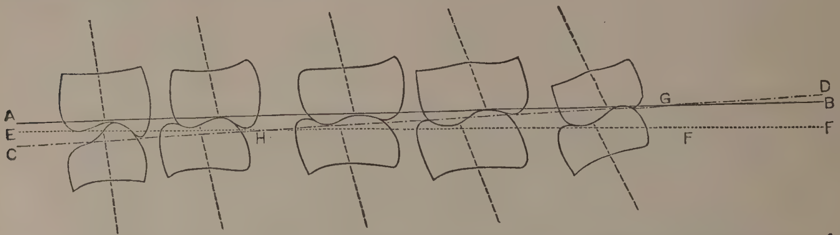

Fig. 32.—Diagrammatic view of the relative height of the buccal and lingual cusps of molar and bicuspid teeth. (Walker.)

In exerting the force by which the food is crushed, the jaw moves to what has been called the position of occlusion, from the various positions which it has assumed in biting through the food placed between the teeth. There are several ways in which the food may be crushed in such movements. It may be done by the action of a cone-shaped point not closely fitting its opposing surface, which is applied to the food and acts as a dividing wedge; or the cone may be received into a depression which it closely fits, the food being simply crushed as between two plane surfaces, or the cone may not fit the depression, there being space or spaces for the crushed food to escape, the cone in

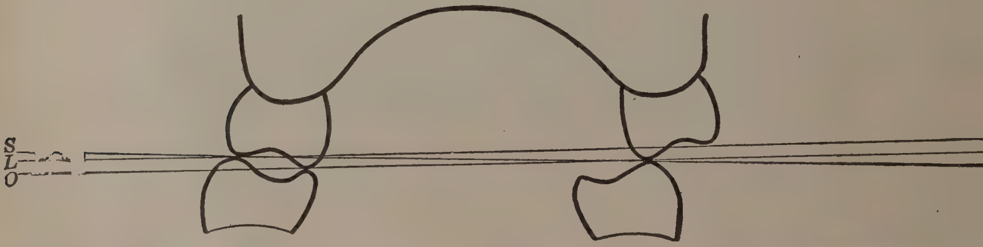

Fig. 33.—Diagram illustrating contact of cusps in lateral excursion of the mandible. Section through jaws at position of second molar. *O P*, line touching lingual cusps of upper molars; *L R*, line touching buccal cusps of lower molars; *S T*, line touching buccal cusps of lower molars, showing the downward movement of the mandible on the right side necessary for contact of the cusps.

the depression acting somewhat as a pestle in a mortar. Two closely fitting plane or curved surfaces, when the force between them is exerted at a right angle to the surfaces, do not act well for crushing except for rather brittle substances. But if in addition to their approximation they slide upon each other, the crushing effect is increased.

A cusp received into an accurately fitting depression does not possess the greatest efficiency for crushing. Clearance spaces must be provided. During the operation of the denture as the food is pressed toward the buccal and lingual surfaces of the teeth, grooves between the cusps and the interdental spaces are provided for clearance. Grooves run down to the bottom of the depressions in the bicuspid and molar teeth, and the chief clearance channels are located between the buccal cusps of the upper and the lingual cusps of the lower. This carries the food lingually above the tongue so that it may be manipulated more easily, while buccally it is carried downward into the sulcus between cheek and teeth, where, because of the peculiar musculature of the cheek and because the lower jaw is depressed below this point when the mouth is opened, the food is again carried in between the teeth. This overhanging of cusps also serves to protect the cheek on the outside and the tongue on the inside from being caught between the surfaces of the teeth.

In addition to the fact that the forms of the occlusal surfaces of the teeth peculiarly fit them to act as the crushing organs of the mechanism, we find that they are adapted for this function in other particulars. They are provided with the means of resisting the wear and stress which the constant activity of the apparatus entails.

The enamel of the teeth, the hardest tissue of the body, forms their external covering. It gives them a hard, resistant, and highly polished surface, and offers its greatest thickness to those parts most exposed to wear. The enamel masses are also arranged to give the best mechanical support in resistance to the force exerted upon the teeth. The bulk of the tooth is composed of dentin which confers the necessary strength.

Resistance to the stress of mastication is provided for by the form and location of the roots of the teeth. These are all modified cones fitting into conical sockets, and as their long axes are generally in line with the direction in which stress is exerted upon them, the mechanical advantage is evident. The force upon the incisors does not always act to force them into their sockets (Figs. 34, 35 and 37). For the upper it serves to drive them forward as well as upward, and is resisted by the flattened labial surface of their roots. The canine is forced upward and outward and the labial surface of its root also serves to prevent displacement in this direction (Fig. 36). The six lower anterior teeth are forced downward and inward, the inclination of their roots and their arch-like arrangement resisting the strain upon them. The principal strain upon molars and bicuspids is vertical, their roots being well disposed to resist it (Figs. 38 and 39). The lateral stress upon these teeth, which is largely determined by the height of their cusps, is resisted by the direction of their roots. As the principal lateral strain upon the upper molar and bicuspid teeth is inward, we have their long axes inclined in the direction to resist this (Fig. 38).

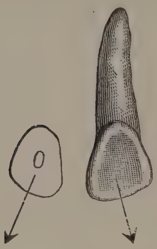

FIG. 34.—Line of resistance to force offered by upper central incisor. (Burchard.)

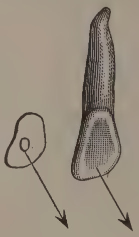

FIG. 35.—Line of resistance to force offered by upper later incisor. (Burchard.)

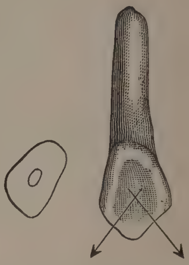

FIG. 36.—Lines of resistance to force offered by upper canine. (Burchard.)

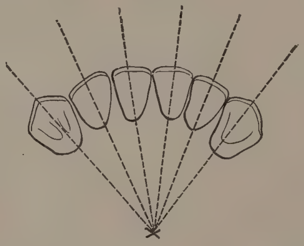

FIG. 37.—Lines of resistance to force upon the lower incisor and canine teeth. (Burchard.)

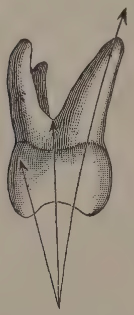

FIG. 38.—Lines of force upon an upper molar. (Burchard.)

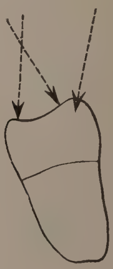

FIG. 39.—Lines of force upon a lower molar. (Burchard.)

The opposite is true of the lower molars whose long axes resist a force tending to displace them downward and outward—the direction in which strain in mastication is applied to them (Fig. 39).

The character of the retentive tissues of the teeth tends to prevent and resist strain upon them. The pericementum is composed largely of connective tissue fibers extending from the tooth to its socket, and so disposed as to support the tooth even under great pressure on its long axis, but by their elasticity permitting slight movement in any direction. The membrane is also highly vascular, particularly in youth, which doubtless also contributes to its resiliency. This mobility enables the tooth to resist far greater force exerted upon it than if it were solidly attached to the bone, and the independent mobility of the teeth makes the denture capable of resisting greater strain than if they were a united mass. The teeth mutually support each other because of their approximal contact, so that each tooth is thus able to resist greater force. The pericementum has upon the tooth a vital protective influence as well as a cushioning effect. Black[1] has reminded us that its tactile sensibility is a constant safeguard against overstrain.

It has been stated that there are a number of characteristics of the typical denture which are variable, and that they are all more or less directly related, and that they vary harmoniously and proportionately.

Those which have been mentioned are:

1. The size and shape of the individual teeth.
2. The overbite of the incisors and the cusp length of the molars and bicuspids.
3. The shape of the dental arch.
4. The curve of Spee or "the compensating curve."
5. The inclination of the long axes of the teeth.
6. The relation of the buccal and lingual cusps of the bicuspid and molar teeth.
7. The shape of the condyle and the inclination of the glenoid fossa.

In what may be called typical dentures variations in any of the above may and do occur without the creation of a departure from the mechanical design, provided they are associated with variations in other characteristics to which they are directly related. The mutual relation of these has been pointed out as they were described. The only item mentioned which is not a characteristic of the denture is the last, which of course determines the path and the manner of movement of the jaw. The relationship existing between this and the anatomical form of the teeth is the most important one to bear in mind. It has been well stated by Walker[2] that "there is a certain definite correlation between the morphology of the morsal surfaces of the teeth" and the path pursued by the condyle.

The foregoing description has been that of the ideal or typical masticatory apparatus rather than the normal or usual. Few dentures absolutely perfect in every particular exist; it is indeed doubtful if any do. A number which are approximately perfect have been used to illustrate this chapter. Nature has been prolific in her provision for man's needs in this regard, and while she has furnished few with a perfect mechanism, yet within the bounds of what may be termed the normal, many dentures exist which, although they fall short of the mechanical design described in many particulars, nevertheless serve their possessors for purposes of mastication in an entirely satisfactory manner. The human organism frequently displays its ability to adapt itself to serious shortcomings in the work of this apparatus, but it must not be forgotten that the greater the departure from this typical design, the less must be the efficiency of the mechanism.

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[1] Dental Cosmos, vol. **38**, p. 476.

[2] Ibid., p. 576.

THE PREPARATION OF FOOD.

Incision.—Having studied the characteristics of the masticating mechanism, we are prepared to discuss the method by which it functionates. Prehension, or the seizing of the food, is a function of the teeth of some of the lower animals but is unnecessary with civilized man. His first act is that of incision, although with the development of cutting instruments for food and the cultivation of a conventional use of them, even incision is confined to few articles. In the performance of this act the lower jaw is depressed from the position of occlusion and carried forward, the condyles moving approximately evenly in their fossæ in this direction, rotation of the jaw about them occurring sufficiently to permit a grasping of the substance to be incised. The food is carried through the lips into contact with the upper incisor teeth, when the jaw is elevated and partly retruded, the edges of the lower and upper incisor teeth being approximately opposite during the movement. The more resistent the food, the more nearly will the teeth be opposed in their course through it. As soon as their cutting edges come in contact, the retraction of the jaw is so combined with elevation that the edges of the lower incisors slide up the lingual surfaces of the upper, the incisal edges passing each other somewhat after the order of shears. In some cases where the normal overbite of the incisors, described on page 39, does not exist, the curve of the occlusal surfaces of the molars is such that the third molar in its advanced position, due to the protrusion of the jaw, is in contact with the second molar during incision, thus tending to relieve the strain upon the incisor teeth. This is usual where there is an edge-to-edge bite, but with a normal overbite it does not occur.

It will be noted (Fig. 18) from the curve of the occlusal edges of the upper incisors, the laterals usually being higher than the centrals, that their edges are first opposed in the center, and thus the shearing action is carried on in both directions from this point. It is also noted that when the edges come into contact the food has been practically severed, and that until this time, the direction of the stress upon the upper teeth is almost that of the long axes of the teeth, while for the lower incisors this is not true until the cutting edges begin to slide upon the upper incisors, the stress up to this time being such as to displace them downward and forward.

Mastication.—Man's diet consists of food of various degrees of physical consistence, and while the tendency of civilization is toward such preparation of the food as to lessen the necessity of mastication, some of it, indeed, requiring none at all, yet the bulk of it demands a thorough trituration to best subserve the body's needs. The principal articles of human diet requiring mastication are meats (animal fiber), vegetable fiber, and cereals, and foods made from them. Some of the other vegetable products have a hard protective covering which must be broken through to give access to the digestive juices, for it has been demonstrated that some of them, as grain for instance, might pass unaltered through the alimentary canal if this were not done. From a mechanical standpoint the essential feature of mastication is to crush these various articles of food in order to break up their physical organization and reduce the size of their separate particles. The object of this operation is to facilitate the action of the digestive fluids upon the food and render its passage through the alimentary canal easily accomplished.

After the food has been incised or after an appropriately sized portion has been introduced into the cavity of the mouth, it is passed back by the tongue to the bicuspid and molar teeth to be reduced to small particles. In accomplishing this the jaw executes two more or less distinct kinds of movements and there are various combinations of them. The first of these is the direct up and down motion of the jaw in which it moves in the sagittal plane; the morsal surfaces are separated and the food placed between them is crushed when they are approximated. The great crushing ability of tuberculated surfaces is a well-known mechanical principle, the cones acting as wedges to divide the food. The efficiency of the denture in this movement is proportional to the height of the cusps, sufficient clearance spaces being necessary, as has heretofore been shown. This motion is peculiar to the carnivorous animals, their masticating efforts being practically limited to it. Black has stated that this kind of masticating motion is used almost exclusively in the mastication of meats by persons with fairly normal dentures. The ultimate position attained by the jaw in this motion is, of course, as nearly that of occlusion as the crushed fiber interposed between the surfaces will allow. The jaw does not always close so that the cusps are exactly opposite their respective fossæ, hence a small sliding takes place to bring the teeth together, but in the main the movement is toward the position of occlusion, the food being squeezed in a pulpy mass buccally and lingually.

The other motion, which in its simplest form is similar to that characteristic of herbivorous animals. is produced during the lateral excursions of the jaw. The mandible is depressed and carried to one side, the condyle on the side toward which it is moving usually remaining in the distal portion of the fossa, that of the opposite side being pulled forward. The jaw is then elevated in this lateral position, the food being interposed, and the rounded buccal cusps of the lower teeth on this side come into relation with the sharp buccal cusps of the upper, the inner cusps likewise touching; the food is crushed and cut, a portion of it being left to occupy the fossæ between the inner and outer cusps. The jaw is then pulled upward and inward toward its occlusal position, the food being crushed between the rounded and strong lower buccal cusps and upper lingual cusps. With this movement is frequently combined a slight protrusion, though this is largely a matter of habit, and is not by any means necessary for the most efficient action of the teeth. While this is occurring on one side, on the other the teeth are not brought into the same functional relations. The high cusps above and below are usually in contact at one or more points, which serves to prevent strain and offers resistance to the elevator muscles of this side which contract simultaneously with those on the opposite side. This side does not functionate during the excursion of the jaw to the other side, because only the upper lingual and lower buccal cusps are in contact. This motion is used in the crushing of cereals and food made from them, and is by far the more effective of the two. It is also used in crushing most of the brittle and very hard substances. In the normal denture mastication of this nature takes place instinctively upon the two sides alternately, although this is largely a question of habit.

	Dr. Head's pounds.	Dr. Black's pounds.
Raw cabbage	16	40–60
Raw onion	4	
Head lettuce	8	23–30
Radish, whole broke	20–25	20–25
Pieces radish, pulverized	10–25	35–40
Corned beef	18–22	30–35
Boiled beef	3	
Tongue	1– 2	3– 5
Lamb chop	16–20	
Roast lamb	4	
Roast lamb kidney	3	
Tenderloin of beefsteak (very tender)	8– 9	35–40
Sirloin steak	10–20–43	
Round of beefsteak, tough	38–42	60–80
Roast beef	20–35	35–50
Boiled ham	10–14	40–60
Broiled ham	10–13	
Pork chops	25–30	20–25
Roast veal	16	35–40
Veal chops	12	
Roast mutton	18–22	

The force required in crushing various articles of human diet, by an up and down motion, has been investigated by Black.[1] He used an instrument consisting of two molar teeth carved from brass, which are forced against corresponding teeth by the direct thrust of a sliding bar. Head[2] has reduced the figures thus obtained by Black by the use of a device for producing a triturating as well as a crushing movement. He utilized "a natural skull with practically perfect molars of average size." This was inverted, arranged with weights suspended from the lower jaw, and "so tipped that the force of gravity would, during mastication, give a sliding or triturating motion." The comparative table, appended on page 58, gives the results in pounds obtained by these two investigators.

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[1] Dental Cosmos, vol. **38**, p. 484.

[2] The Human Skull Used as a Gnatho-dynamometer to Determine the Value of Trituration in the Mastication of Food; paper read before Union Meeting, Washington, 1906.

Mastication is a voluntary act, but the coördinating mechanism once having been set in motion by the will, it continues reflexly and automatically, and is independent of conscious action. The food, having been passed into the mouth, is carried back to the molar and bicuspid teeth and crushed after the manner already described. The tongue is the principal agent in keeping it between the crushing surfaces. The tonic contraction of the orbicularis oris in the lips and the buccinator in the cheeks opposes the tongue, active action of either occurring when necessary, while within the arch the tongue shifts the food from side to side between the morsal surfaces as may be necessary, the rugæ affording a rough surface upon which it may be rolled. The saliva, which is constantly secreted in the mouth and which flows in greater abundance under the stimulation of the presence of food and of mastication, is mixed with the food. It softens the food, dissolving some of its soluble constituents, adds a digestive ferment, and its mucin assists in agglomerating and lubricating the mass for deglutition. It also lubricates the soft tissues which play about the teeth. During the process of mastication the teeth not only crush the food, but also functionate as organs of exquisite tactile sensibility, giving instant knowledge of the location of the alimentary particle and of its physical consistence.

Deglutition.—After the food has been masticated and mixed with saliva, it is gathered into a bolus upon the tongue, the edges of which are curved upward to form a gutter. The anterior portion, being lifted by its intrinsic muscles and the stylo-glossus, is in contact with the anterior portion of the palatal vault, the rugæ affording here also a roughened surface against which it is placed. The soft palate is then lifted by the levatores palati to touch the posterior wall of the pharynx, which has been bulged forward to meet it by the action of its superior constrictor. At the same time the funnel-shaped pharynx is brought up by the palato-pharyngeus and the stylo-pharyngeus to cover the mass, which is then shot past the pillars of the fauces by the pressure exerted upon the tongue by the contraction of the mylo-hyoid and of the hyoglossi (Kronecha and Metzger); the opening into the larynx is closed by the contraction of the lateral crico-arytenoids and the constrictors of the glottis, by the elevation of the larynx, and partly by the epiglottis, although the part taken by the latter structure is of small importance. The peristaltic action of the esophagus then carries the food to the stomach.

THE LOSS OF THE TEETH.

It is beyond the purpose of this work to discuss the causes which result in the loss of the teeth. Suffice it to say on this subject that the absence of the teeth is so frequent an accompaniment of old age as to be looked upon as one of its usual features. An edentulous condition is not the result of natural physiological processes analogous to those by which the accommodation fails from a weakening of the ciliary muscle and a hardening of the crystalline lens, or the hair turns gray in old age from a disappearance of its pigment. The teeth are lost from pathological processes which either receive no treatment or are unsuccessfully treated; from accidental causes; or are removed surgically in the treatment of diseased conditions. Unfortunately it frequently happens that they are lost from these causes before the period of old age.

Effect upon Mastication.—The effect of the loss of the teeth upon the masticatory function may be readily understood since their part in it has been described. As each tooth performs a definite portion of the work of the mechanism, its loss is followed by a definite interference with that work. The loss of one tooth deprives the opposed series of one of its antagonists, and renders it functionally useless at this point. The loss of a tooth also deprives the adjacent teeth of the support of approximal contact. While some teeth are more important than others and their loss is followed by more serious consequences, yet in general, the loss of teeth having antagonists increases proportionately the deficiencies of the apparatus.

The function peculiar to any class of teeth is affected by their loss. When the incisors are missing, the incisive function suffers; when the molars and bicuspids are absent, the trituration of the food is interfered with. The function of the lost teeth is partly taken up by those which remain. The incisors are frequently called upon to perform the work of the molars and bicuspids, a service for which they are in no degree suited, and one which ultimately causes them to be unduly abraded, and also results in an approximation of the jaws distally, and establishes conditions which complicate the subsequent insertion of artificial dentures. The molar and bicuspid teeth remaining on one side of the mouth may have to perform all the mastication which should have been divided between the two sides. This condition is also followed by unnatural consequences, because the apparatus is designed for symmetrical operation. The usual result is a distortion of the normal relation of the jaws, and a movement of the remaining teeth under the unnatural masticatory force.

The assumption of the whole masticatory function by a portion of the denture may continue satisfactorily for a while, and the digestive process may not suffer, because in the alimentary tract there occurs a large amount of adjustment to the conditions in the mouth. The more slowly the teeth are lost, the more readily will this adjustment take place. The food habit usually alters naturally in the course of the process, articles requiring little trituration or those previously subdivided being utilized in increasing proportion; this being especially true as the period of old age is reached. There is also an alteration in the secretions to harmonize with the changed conditions. Lefoulon has pointed out the compensatory increase in the flow of saliva which takes place at this time.

It is evident, however, that the metabolic balance must sooner or later be disturbed by the decline of the masticatory apparatus. Oefele[1] has shown that there is a marked failure in the digestion of starches by those who have lost their molar teeth, and Richard[2] has called attention to the fact that in some animals, vegetable particles may go through the alimentary canal practically unchanged, unless their natural protective covering had been broken by the teeth.

When mastication is defective, not only is there a failure to assimilate the food, but since particles of too great size for gastric digestion are swallowed, peristalsis is delayed, fermentation takes place, and pathological processes ensue in the stomach and intestines. The gastritis and enteritis which are frequently observed in edentulous patients give clinical evidence of the truth of this assertion; and the removal of the cause—that is, the restoration of the masticatory function by the insertion of satisfactory artificial dentures, is usually followed by a disappearance of these conditions.

CHANGES IN THE JAWS FOLLOWING THE LOSS OF THE TEETH.

The principal changes which occur in the jaws after the loss of the teeth take place in the alveolar process. This structure is developed with the teeth, furnishes them with support, and is largely resorbed after they are lost. When a tooth of the permanent denture is extracted, its socket in the process of repair is partially filled up with cancellated bone tissue, which in turn becomes covered over with cortical bone tissue and mucous membrane. There is a resorption of the margins of the socket, particularly of those corresponding to the outer and inner plate, and a general rounding and lowering of the alveolar process, and a loss of contour at this point. This change is repeated each time a tooth is lost, so that after the loss of all the teeth, the alveolar ridge persists as a rounded ridge. The process of resorption differs somewhat in the two jaws and differs in accordance with the conditions which have preceded or attended the loss of the teeth.

When resorption of the margins of the sockets in the condition commonly designated pyorrhea alveolaris has preceded the loss of the teeth, the alveolar ridge will be found but poorly marked, and the overlying soft tissues which have been the seat of chronic inflammation will be found soft and non-resistant. This furnishes the poorest base for an artificial denture.

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[1] Dental Rec., vol. **25**, p. 160.

[2] De la prothèse dentaire, Thésè pour le doctorate en médecine, Paris, 1866.

The Upper Jaw.—After the loss of the teeth the maxillæ undergo change in form and size. Most of the resorption of the alveolar process takes place at the expense of the external plate, the internal plate being modified only as resorption of the top of the ridge proceeds. The resorption of the external portion of the ridge generally occurs progressively. The ridge becomes more rounded, lower, and gradually less pronounced (Fig. 43). When the alveolar process was originally high and narrow, the resorption of the external plate reduces its thickness and it persists as a thin well-marked ridge. (Figs. 40 and 44). The ultimate state which the jaw may reach is that in which the whole roof of the mouth is flat (Figs. 41 and 42). This occurs only in unusual cases. In extreme cases there is a falling in of the cartilaginous septum of the nose from the resorption anteriorly (Fig. 45).

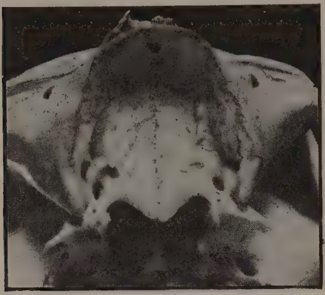
Fig. 40.—Edentulous upper jaw, showing thin alveolar ridge.

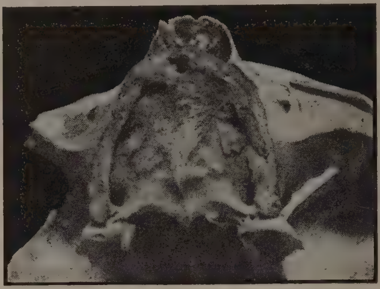
Fig. 41.—Edentulous upper jaw, showing flat alveolar ridge.

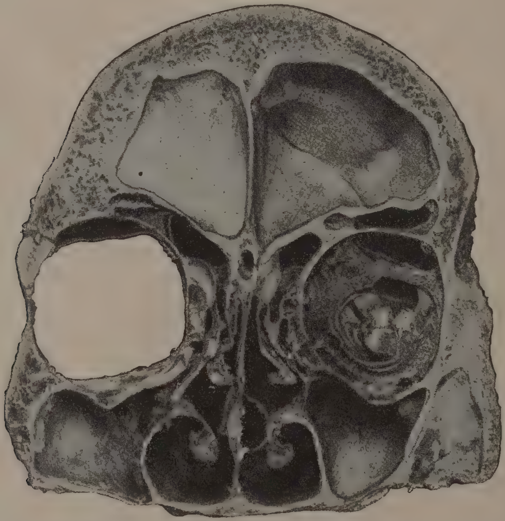
Fig. 42.—Section showing extreme resorption of the alveolar ridge. (Cryer.)

The palatal vault is the part of the jaw in which the least change occurs, as the resorption takes place on the external side of the ridge and on top. This may be noted by reference to Fig. 41, which shows an edentulous jaw. When this is compared with one with the full complement of teeth (Fig. 15), reference to the anterior palatine foramen, the position of which does not change after the loss of the teeth, and which in the living subject corresponds approximately to the incisive pad of the rugæ, will show that most of the resorption has occurred external to this point.

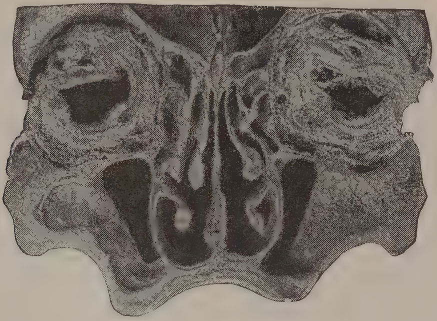

FIG. 43.—Section showing considerable resorption of the alveolar ridge. (Cryer.)

The extreme degrees of resorption of the process are caused by stimulation of the giant cells from pressure in masticating the food directly upon the gums, from ill-fitting dentures, or from other causes. Properly fitting artificial dentures prevent, in a great measure, this resorption. Artificial dentures arranged with occlusion at one point only are frequently productive of a localized resorption of the process, which complicates the successful fitting of new dentures. One of the most commonly observed cases of this sort is that in which a full upper artificial denture is antagonized only by the six or eight lower natural anterior teeth, there being no teeth posterior to this point, resorption

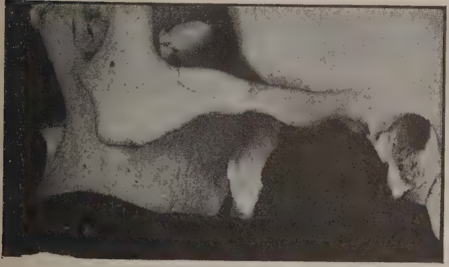

FIG. 44.—Profile view of edentulous upper jaw, showing thin alveolar ridge.

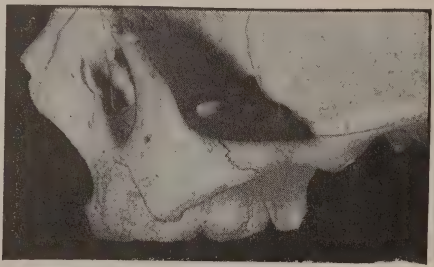

FIG. 45.—Profile view of edentulous upper jaw, showing considerable resorption.

of the alveolar process of the maxillæ in front occurring as the result of of the undue pressure upon it.

The Lower Jaw.—The changes occurring in the alveolar process of the lower jaw are similar to those which occur in the upper. In discussing the phenomena of growth and resorption in the mandible, the character and extent of these changes are well described by Sir John Tomes as follows: "In the great majority of specimens a small foramen is situated in the median line immediately above the upper pair of tubercles (genial), and when present, this may be selected as a point from which to take . . . . . dimensions. Unfortunately it is sometimes wanting or is represented by a similar aperture below the spinæ mentales. In a series of jaws taken from very old subjects in whom the teeth had been lost and the alveolar process had been absorbed, the foramen holds to its original position. If these specimens are subjected to measurement we find that this aperture is within $\frac{1}{12}$ to $\frac{3}{12}$ inch of the alveolar margin, showing a loss in the oldest jaw of $\frac{9}{12}$ while it is separated from the lower border of the jaw by $\frac{6}{12}$ inch, the loss in this direction being inappreciable" (Fig. 46). The alveolar plates of the mandible, according to Cryer, resorb more evenly than in the upper jaw, usually a small ridge remaining to indicate the position of the former process and teeth. The external oblique line which descends from the anterior margin of the coronoid process, is, always external to the location of the former alveolar ridge. In cases of extreme resorption the ridge is entirely obliterated, and commonly there is less ridge in the lower jaw than in the upper.

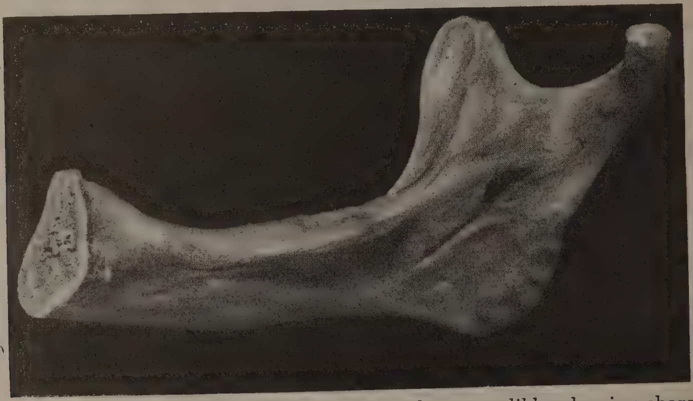

Fig. 46.—Internal view of the half of an edentulous mandible, showing character of the resorption of the alveolar process. There is considerable resorption posteriorly, but very little in the anterior portion of the process, as the teeth have been lost here only a short time.

Only slight change occurs in the body of the bone, as has been mentioned above. A noticeable change, however, occurs at the angle of the jaw. Fig. 47 illustrates the cycle of change occurring in this region between the time of the completion of the deciduous denture and old age. Since the vertical distance between the jaws is increased in adult life to accommodate the permanent denture, there must necessarily be a change in the angle of the jaw to make this possible. The average angle made by the body and ramus of the jaw in an adult is about 120 degrees. While the natural teeth are in position, no change occurs in the relation of the jaws except a slight approximation due to the wear of the teeth. If the teeth remained there would be no appreciable alteration of the angle of the jaw. As age advances and as the back teeth are lost, the powerful traction exerted by the muscular apparatus upon the anatomical angle of the jaw, the forward end of the jaw being in occlusion through the anterior teeth, causes a flattening

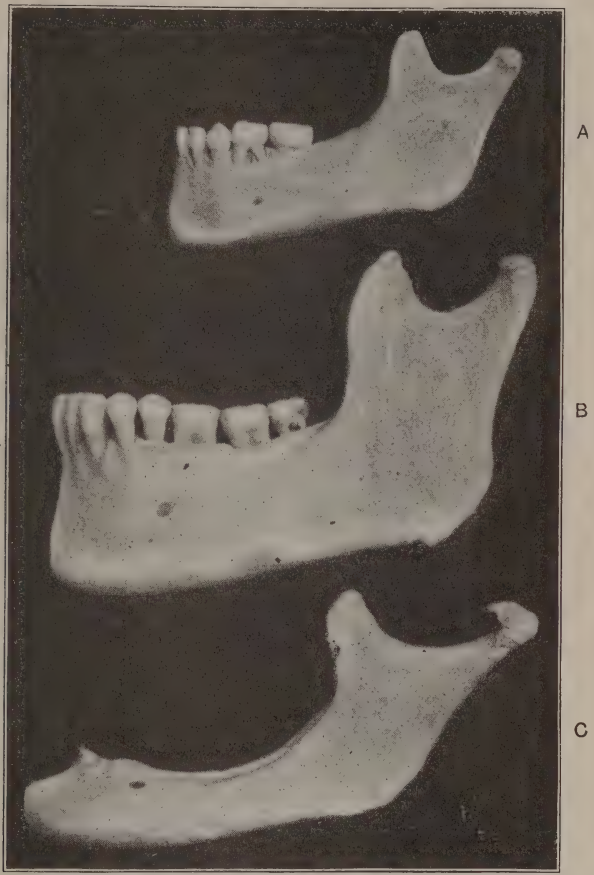

FIG. 47.—Specimens showing the angle formed by the ramus and the body of the mandible. A, at the time of completion of the temporary denture; B, in adult life; C, in old age. (From a photograph of specimens in the Wistar Institute of Anatomy.)

of the angle and at the same time the symphysis is carried forward. After all the teeth are lost, this becomes still more evident. Slight change occurs also at the condyle where a general flattening takes place. There is also an alteration of the glenoid fossa corresponding to this. Its pronounced margin is lost and it becomes in general more flattened (Fig. 4, *D* and *E*).

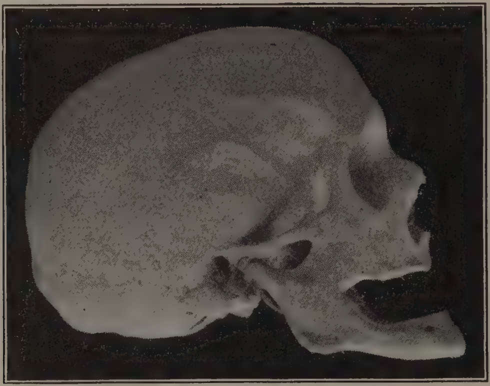

Fig. 48.—Skull showing relation of edentulous jaws; profile view. (From photograph of a specimen in the collection of Dr. M. H. Cryer.)

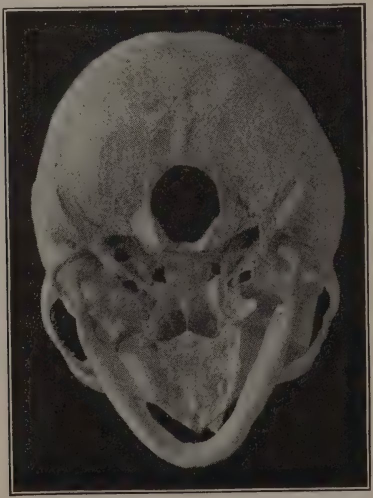

Fig. 49.—Skull showing relation of edentulous jaws; viewed from below. (From photograph of a specimen in the collection of Dr. M. H. Cryer.)

The Relation of the Jaws.—"As the resorption of the alveolar process goes on, the vertical distance between the body of the lower jaw and that of the upper is lessened, while the natural difference in their width is increased. The area of the upper jaw becomes smaller in proportion to that of the lower, the axes of the mandible extending further outward. In the endeavor to close the jaws under these circumstances, the lower is projected further forward as it rises to meet the upper, until, in extreme cases, it may pass absolutely outside of the upper.[1]" Figs. 48 and 49 give two views of an edentulous skull and show the relations of the jaws.

VOICE AND SPEECH.

Voice.—Voice is the audible sound originating in the vibrations of the vocal cords and reinforced by the resonance of air cavities situated in the head and chest. The apparatus by which it is produced consists of: (1) The lungs, chest walls, and muscles of expiration, which furnish the motive power; (2) the larynx, in which are situated the vocal cords; (3) the chest cavity below, and pharynx, mouth and nose above, which constitute the resonating chambers. When the air is forced out of the lungs by the contraction of the chest muscles and at the same time the vocal cords are approximated and made tense, their edges are set in motion and a sound is emitted. The cords themselves are capable of producing only a feeble sound,[2] but when they vibrate close to self-sounding bodies as the air in the cavities above mentioned, this air is thrown into sympathetic vibration and the volume and character of the original sound are altered. The sound made by the cords is not a simple musical tone but is a complex "note made up of a fundamental tone combined with upper partial tones," overtones, or harmonics, of which as many as sixteen in some instances accompany the fundamental.[3] When the air contained in the resonant cavities is thrown into vibration, it is capable of emitting a musical note, the pitch of which depends either upon the size of the cavity or upon the size of the opening by which it communicates with the external air. The larger the cavity or the smaller its opening, the lower will be the pitch and *vice versa.* The resonant cavities reinforce either the fundamental tone, or the harmonic of the laryngeal sound, which corresponds to the pitch to which they are tuned, so that alterations in their shape largely determine what is known as the quality of the voice.

The voice possesses in common with other musical sounds three characteristics: (1) Pitch; (2) loudness; (3) quality. The pitch is determined by the tension of the vocal cords; the tighter they are stretched the higher will be the pitch. Loudness is proportional to the strength of the expiratory blast, and is also related to the resonance of the cavities above and below the larynx. The quality of the voice is dependent upon the character or form of the sound wave, and is related to the number and relative intensity of the overtones or harmonics which accompany the fundamental tone. The form of the wave is determined by the state of tension of the vocal cords, and by the form and size of the air cavities, which act as the resonating chambers. The air cavities, whose pitch may be changed at will, contribute by their resonance, now to reinforce this tone and now that, so that any overtone or the fundamental may be intensified by change in the shape of the resonant cavities.

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[1] Cryer, M. H.: Internal Anatomy of the Face, p. 168.

[2] Sewall: American Textbook of Physiology, vol. 2, p. 421.

[3] Helmholtz, quoted by Sewall: American Textbook of Physiology, vol. 2, p. 435.

The esthetic value of a human voice depends upon the number, character, and relative intensity of the overtones which accompany its fundamental tone. This tone quality is determined by the power of adjustment of the larynx, in which the tones are produced, and by the precision of the muscular adjustments regulating the resonant pitch of the air cavities in which the tones are accentuated. The capability of the larynx is the more important of these factors, but it is evident that ability to correctly attune the resonating chambers is a necessary adjunct.

The mouth is one of the most important of these resonant cavities. Its form is altered by the depression of the mandible and by the movements of the tongue. The soft palate also assists in this process, its chief function, however, being to separate the mouth and nose cavities. Increase in the size of the mouth causes a corresponding lowering of its pitch. The lips serve to increase or diminish the opening communicating with the outside air; the larger the opening, the higher will be the fundamental note of the cavity; the smaller the opening, the lower will be the note.

The pharynx is changed in shape by the rising and falling of the larynx, while the resonance of the nasal chambers and the air cells communicating therewith cannot be altered at will. The resonance of these cavities may be controlled only as they are added to or separated from the mouth space by the action of the soft palate and tongue.

Those portions of the air cavities which are uninfluenced by muscular action are but passive factors in regulating their resonance. It is by the adjustment to these of the soft and movable parts that variations in their resonance are produced. Therefore the change in the fixed parts of the mouth caused by the loss of the teeth, necessitates a change in the muscular adjustments, and requires new coördinations on the part of the tongue. The lips and cheeks, which are no longer supported by the teeth, fall in and complicate the process of adjustment. This change in the fixed portion of the mouth is almost always succeeded by changes in the qualities of the voice, although the speaking voice is altered less than the singing voice, in which more precise muscular coördination is required.

Speech.—Articulate speech by means of which man communicates his thoughts, has for a long time been divided by scholars into vowel sounds, or those produced in the larynx and modified by the position of the various mouth parts, and consonant sounds, which are noises accompanying the other sounds and are largely made in the mouth.

Language consists in the regular progression of these sounds, which either singly or in combination represent ideas.

Vowels.—The vowels are the true laryngeal sounds, originating in the vibration of the vocal cords and determined by their state of tension and by the peculiar resonance of the pharynx, nose and mouth. For any given vowel the posture of the mouth parts is the same, that is, this cavity is tuned to a definite pitch, the difference in the actual pitch of the vowel being determined by the tension of the vocal cords and by the size of the pharynx. In tuning the cavity for the sounding of *ah* (*father*), *o* (*own*), and *oo* (*shoot*), the tongue does not touch the palatal vault, but in *a* (*ate* and *e* (*met*), its sides touch the molar and bicuspid teeth and adjoining mucosa. The vowels are closely related, for the position of the mouth parts for one vowel easily changes to that for another. It is evident therefore that the changed conditions of the mouth incident to the loss of the teeth require new muscular adjustments to enable the mouth cavity to be tuned to the proper pitch for each vowel.

Consonants.—In the production of most of the consonant sounds, a current of air is interrupted or stopped at some point during its exit from the lungs, the noise resulting therefrom being the consonant sound. Some consonants, however, may be sounded only in conjunction with a vowel, in which case the consonant is only a superadded noise to the laryngeal sound and is due to the peculiar resonance imparted by the mouth and nose cavities when they are properly disposed for the formation of the consonant. In other consonants the sound originates in the mouth, from vibration of the mouth parts caused by an incomplete obstruction to the air current, while in others there is an explosive sound due to the sudden stoppage or starting of the air current.

The following table[1] gives a classification of the consonants according to the place at which they are formed:

Place of articulation.	Oral.				Nasal continuous sonants with voice.
	Momentary.		Continuous.		
	Surds without voice.	Sonants with voice.	Surds without voice.	Sonants with voice.	
Lips	p	b	...	w	m
Lips and teeth	...	...	f	v	
Tongue and teeth	...	...	th (in)	th (y)	
Tongue and hard palate (forward)	t	d	s, c (ity)	z, r	n
Tongue and hard palate (back)	ch	j	sh	z, r	
Tongue, hard and soft palate	...	...	...	y, l	
Tongue and soft palate	k, c (at)	g	...	...	ng
Various places	h				

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[1] Sewall: American Textbook of Physiology, vol. 2, p. 437.

A careful study of this table will show that the factors determining any given consonant are the strength of the expiratory blast, the presence or absence of voice, and the position of the mouth parts.

Mechanism of the Production of the Consonant Sounds.—In the formation of the P and B sounds, the air blast meets no interference in the mouth because of a narrowing of the channel, but is interrupted at the lips by their sudden opening or closure (Fig. 50). In P there is greater air pressure and greater suddenness in the stoppage or starting of the current. In K and G also the channel is unaltered, stoppage of the blast occurring at the posterior portion of the palatal vault by the application of the base of the tongue to the soft palate. In G the air pressure is not so great as in K and the tongue touches a larger area. In L and M and NG the channel is not changed by the application of the sides of the tongue to the vault. In L the tip of the tongue touches the process back of the incisors, while the air current divides and escapes around its sides. In M and NG the air current escapes through the nose.

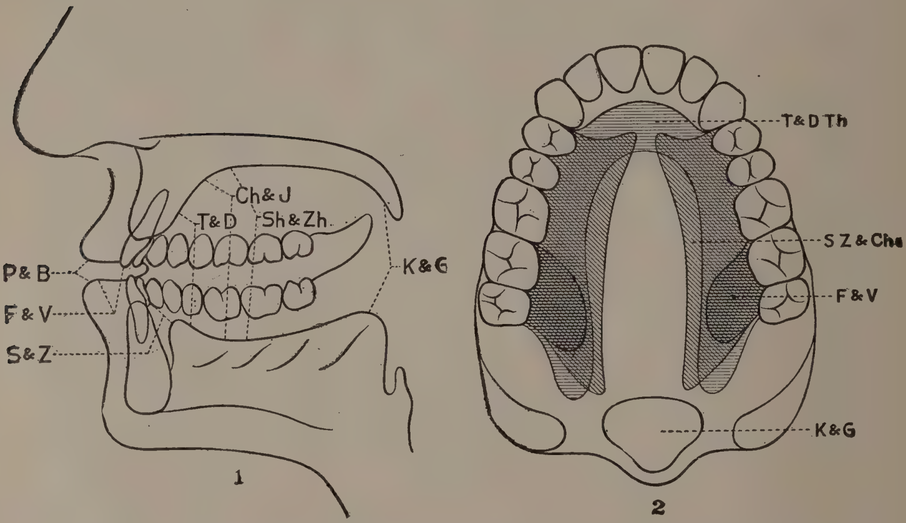

Fig. 50.—1, diagrammatic drawing showing place of articulation of the consonant sounds; 2, drawing showing contact of the tongue with molars and bicuspids in the formation of certain consonants.

In all the other consonant sounds except H, an air channel is made by means of the tongue to direct the blast either upon some point at which there is a partial obstruction or upon some point at which it is stopped. For this purpose the tongue is applied to the sides of the palatal vault touching the molar and bicuspid teeth and the process adjoining, and forms a sort of gutter through which the air is expelled. The position and area of this contact varies with the different letters.

In the formation of T and D the lips are open and the tongue touches the alveolar border with its tip and sides, the tip being depressed as the current of air is ejected. In T the pressure of the blast is greater than in D. In CH and J the tongue is pressed upon the alveolar border at its sides and tip, and the air current is forced between the tip and the anterior portion of the palate. The noise is made between the palate and the tip of the tongue.

In N the oral cavity is closed by the placing of the tip of the tongue against the palate instead of by the closure of the lips as in M. The air escapes through the nose in these consonants, and a peculiar nasal resonance is added to the voice sound.

In articulating the sounds S, Z, Th, Sh, Zh, F and V the air current produces a blowing sound due to its impingement upon some portion of the channel. In the F and V sounds the lower lip is in contact with the incisal edges of the upper teeth, the tip of the tongue being pressed against the lower incisors, while its sides touch the last molar teeth and alveolar border, and guide the air between the lip and teeth. In the formation of S the air is forced past an incomplete obstruction, the edges of the adjacent tissues being set in vibration by the current. The teeth are almost in contact, the lips slightly open, the tongue curls upon the sides to touch the molar and bicuspid teeth as far forward as the canine and the adjoining palatal vault, leaving a narrow opening in front for the egress of the air. The end of the tongue touches the lower incisor teeth, and the sound is caused by the impingement of the air upon the edges of the closed teeth. Z and C (soft as before E and I) are made in the same way, the difference in the intensity of the blast differentiating them.

In Sh and Zh the air is forced by two obstructions, one caused by the arching up of the tongue to nearly touch the palate, the other caused exactly as in S. X is a combination of the S and K sounds.

In Th the tip of the tongue is placed between the upper and lower incisors, the air channel being formed by its sides as in some other consonants. The edges of the upper teeth are set in vibration by the air.

"Lingual R" is produced by having the sides of the tongue in contact with the molar teeth and palate to direct the current upon the tip of the tongue, which is curved upward toward the palate and thrown into irregular vibrations by the blast.

In H[1] the air current meets no obstruction in the mouth, the vibrations producing the sound of the consonant being those of the separated vocal cords. As W is a combination of H and V, its production needs no separate description.

The above description is that of the method of producing these sounds when the apparatus is in its normal state. A change in any of the parts concerned in this process must result in an interference with the correct articulation of the sounds.

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[1] Sewall: Op. cit., p. 438.

It will be seen that so far as the part taken by the mouth in the production of these sounds is concerned, interference with the mechanism by which the air channel for a given consonant is formed, or with that by which the air is obstructed or stopped, must necessarily be followed by an interference with the proper articulation of that sound. The channel is formed by the adjustment of the tongue to the teeth and the sides of the palatal vault, and the obstructions and interruptions are made through contact of the tongue with the teeth, or the hard or soft palate, or of the lips with each other, or with the teeth. The loss of the teeth, the resorption of the process, which alters the form of the palatal vault, and the change in the relation of the jaws must all have a serious influence upon articulation. This is also complicated by the falling in of the lips and cheeks which are supported by the teeth and alveolar process. The tongue is the principal organ of articulation and may learn to accommodate itself greatly to the change in the parts to which it is applied in the production of the sounds, but it is evident in some instances that satisfactory adjustment cannot take place.

The loss of the incisor teeth affects the sounds articulated in this region. When a single upper incisor is missing, at this point there is an escape of air in some of the coördinations in which it should be confined, and the sound of S seems to be made. One of the commonest defects from absence of the incisors is in the formation of Th, the air escaping and giving an S sound instead. When the upper incisors are lost, the F and V sounds are difficult to make, the lower lip having to accommodate itself to the alveolar ridge or to the upper lip, and the sound approximating P or B. In some cases the S sound itself is difficult, especially if both upper and lower incisors are missing, Sh and Zh being similarly affected by this condition. T and D are also sometimes difficult to enunciate, especially if there has been much resorption of the alveolar process at the point where the tip of the tongue presses.

As the molar and bicuspid teeth and adjoining mucosa form part of the lateral walls of the air channel in the enunciation of a number of consonants, deficiencies here affect speech also. The tongue cannot close the sides of the air passage, and the current escapes into the cheeks. T, D, Ch, T, Th, Sh, Zh, S, Z and C are principally affected and especially so when followed by the vowels A or E, contact of the tongue with the sides of the vault being also necessary in making these vowel sounds. F and V may occasionally suffer, and sometimes the tongue cannot shut off the air in N and it escapes into the mouth, destroying the full nasal resonance characteristic of this letter.

THE EXPRESSION OF IDEAS AND EMOTIONS BY THE FACE.

The expression of thought and feeling in man is accomplished for the most part in three ways: By gesture, by speech and by writing.

Speech is the means in most universal use, gesture being chiefly employed to supplement language, while the utility of writing is naturally restricted because of the conditions required for its performance. Besides containing the organs of articulate speech, the face performs expressional services which are not included under any of the above headings. These consist of the movements of associated groups of facial muscles which occur simultaneously with the existence of certain emotions or which express some idea of the mind. The muscular movements and the effect they produce upon the countenance are the accompaniment and the outward manifestation of the psychic state. According to Mantegazza[1] they have two diverse functions; they may replace or complete language, or they may defend the nerve centers or the parts of the body against dangers of different kinds. The forms of facial expression are the same throughout the world[2] and are too familiar to require description.

As one of the most mobile features of the face, the mouth participates largely in its expressive movements. The loss of the teeth interferes with the performance of this function of the mouth; it is purposed therefore to give a brief account of the mechanism by which the facial movements are effected, to point out the part taken by the mouth, and to indicate in what way the absence of the teeth interferes with the muscular action.

Before discussing this mechanism, however, it will be necessary to clearly differentiate between the terms "facial expression" and "the expressive movements of the face." The former alludes to the countenance, its form, contours, surface, muscles—in short, its anatomy; while the latter refers to the contraction of the facial muscles which produces the movements expressive of ideas and emotions. Facial expression will be treated under a separate heading.

The Facial Mechanism of Expression.—The mechanism of the expressional movements of the face consists of: (1) A bony framework, the facial skeleton; (2) the muscular apparatus, technically referred to as the muscles of expression; (3) the connective tissue, fat, and overlying integument which complete the face.

The facial portion of the skull gives form to the countenance. It also contains some of the special sense organs which are features of the face, and it affords points of origin for the muscles of expression. The skin of the face is very thin, elastic, and loosely adherent to the underlying structures. Over the nose, however, it closely adheres to the bone and cartilage, and over the chin it is closely united to the mandible through the medium of the intervening tissue. The superficial fascia underlying the skin is intimately united to it. It is very loose and cellular, contains large amounts of fat, and permits great mobility of the integument. The facial muscles, illustrated in Fig. 51, are numerous. For the most part they are superficial and are closely

[1] Physiognomy and Expression, p. 80.

[2] Darwin, C.: The Expression of the Emotions in Man and Animals.

attached to the under surface of the skin. This arrangement permits them to produce in the skin the folds and depressions associated with their movements.

The facial muscles of expression (Fig. 51) may be divided into three groups—those centering about the eye, about the ala of the nose, and about the mouth. They are all concerned in the expressive movements of the face, but as we are interested only in the part played by the mouth, we shall discuss only the muscles operating in this region.

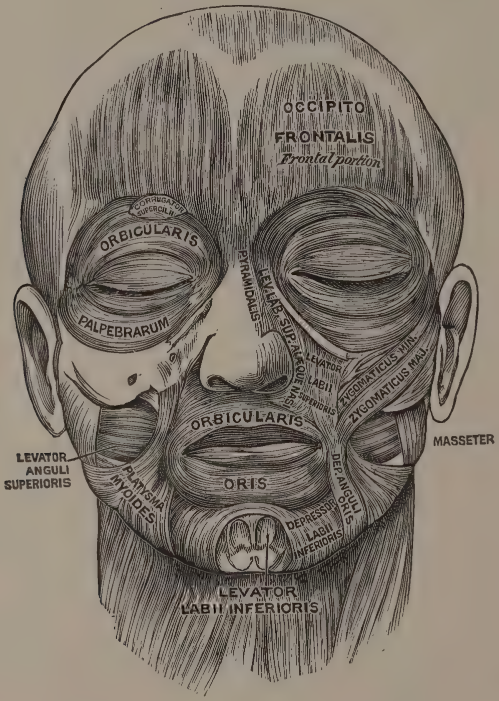

Fig. 51.—The facial muscles of expression.

The orbicularis oris which surrounds the aperture of the mouth is the common meeting ground of the muscles of this group. It consists of two portions—the labial, which occupies the red border of the lip, and is narrow, thick, and regular, and the facial, which is wider and thinner, and spreads out into a wide band just beneath the skin around the oral orifice. Joining these two portions are a large number of muscular fibers which run antero-posteriorly from the skin on the outside to the mucous membrane on the inside. This muscle constitutes the larger portion of the substance of the lips, and gives them their fleshy characteristics. The labial portion of the orbicularis has no attachment to the bone beneath it. At the angle of the mouth it is deeply situated and intimately connected with the buccinator muscle, decussating fibers of which pass above and below this point to be lost in the upper and lower lip. The facial portion has only three small bony attachments on each side. The largest of these are the naso-labial slips, which are slender bands passing up to be attached to the anterior nasal spines, and which correspond on the external surface to the philtrum. Two other slips are attached to the incisive fossæ in the upper jaw, and two smaller slips are inserted in the incisive fossæ of the mandible. The orbicularis is not truly speaking a sphincter muscle as that term is applied to orificial muscles of other parts of the body. It is doubtful if any of its fibers are continuous around the aperture. When the labial portion alone contracts, it everts the lips and diminishes the width of the mouth. The facial portion serves to press the lips against the teeth and adjoining process. Its two portions oppose the other mouth muscles.

Arranged radially about the mouth and united to the orbicularis are the other muscles of this group. They are the levator labii superioris alæque nasi, the levator labii superioris proprius, the levator anguli oris, the zygomaticus major, the zygomaticus minor, the depressor anguli oris, the depressor labii inferioris, the levator labii inferioris and the risorius.

The points of origin from the bones of the face and the points of attachment to the orbicularis indicate the line of action of these muscles. The anterior teeth and alveolar mucosa form a base upon which the tissues of the lips may be moved by them. The mucous membrane is lubricated by the saliva and permits an easy sliding of the lips upon the underlying structures. The canine tooth and eminence are especially important as a base of support for these movements. They underlie the corner of the mouth and afford a prominence over which the lips may be pulled by the muscles attached to the angle of the mouth.

The action of the individual muscles constituting this group has been carefully investigated by Duchenne,[1] who has given a detailed account of their effect upon the countenance. It is beside the purpose of this work to discuss the significance of these movements in great detail. The reader is referred to the literature on the subject for more minute particulars. In order, however, that the reader may understand the usual meaning of the contraction of these separate muscles, the following account of their action is appended.

The levator labii superioris alæque nasi is the principal muscle in the expression of contempt and disdain. It dilates the nostrils and raises the upper lip and draws it slightly forward, and with the other levator muscles increases the prominence of the cheek below the orbit. It helps to develop the naso-labial fold. When it contracts with the other levator muscles of the upper lip, an appearance of sadness and grief is produced. The levator anguli oris draws up the angle of the mouth, pushing up the lower eyelid as in crying. The zygomaticus major is the muscle of joy or laughter. It draws the corner of the mouth backward and a little upward. The zygomaticus minor assists in drawing upward and outward and backward the outer corner of the upper lip but not the corner of the mouth. It produces an expression of sadness. The depressor anguli oris (triangularis menti) draws the corner of the mouth backward and downward and is necessary in the expression of sadness or grief. The depressor labii inferioris (quadratus menti) draws the lower half of the lower lip downward and a little outward. With its fellow of the other side it draws the lip directly down and slightly everts it. It is used in the expression of irony. The levator labii inferioris acts with its fellow in raising the lower lip. It protrudes the chin, as in pouting, and produces dimples in the skin of the chin. It is used in the expression of doubt and disdain, especially when aided by the triangularis menti. The risorius or muscle of Santorini is ordinarily spoken of as the smiling muscle. It draws the corner of the mouth directly backward and produces what is known as the "sardonic grin." The platysma myoides muscle must be mentioned in this group because a few of its fibers really constitute the risorius muscle. It is attached above mainly to the subcutaneous periosteum of the lower jaw from the symphysis backward. Its middle and anterior parts assist in depressing the jaw, while its posterior or lower parts are largely attached to the corner of the mouth, and act to draw the lower lip and angle of the mouth downward and backward, and thus assists in the expression of grief and fear.

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[1] Mecanisme de la physiognomie humaine ou analyse électro-physiologique de l'expression des passions, Paris, 1876.

It will be noted that the buccal orifice and its surroundings are molded to the teeth and alveolar process by the tonicity of the facial portion of the orbicularis and the muscles which connect with it. The loss of the teeth and the subsequent resorption of the process are followed by a falling in of these tissues. Inasmuch as they are no longer supported upon a solid basis, their movement is restricted in amount and in direction. The muscles which serve to carry the lips upward or downward are not so much hampered in their action as those which draw the lips and the mouth backward. This limitation is more particularly due to the absence of the canine tooth and its eminence than to anything else. All expressive movements of the face in which part is taken by the oral muscles are limited after the teeth have been lost.

In a succeeding chapter the restoration of the various functions of the face and mouth by artificial dentures will be discussed. It is desirable that the student should be familiar with the effect of the contraction of each of the muscles of expression, in order that he may not impart to the countenance any unnatural look caused by too great fulness of the artificial denture at any point. A denture which produces the same effect upon the countenance which the contraction of any muscle or muscles causes will impart to that countenance the expression associated with the contraction of the muscles so distorted.

FACIAL EXPRESSION.

The human countenance is made up of the features of the face. Facial expression may be regarded as consisting; first, of the features of the face, which are considered from a purely anatomical standpoint, and are the result of natural endowment; and second, of a certain impress made upon these features by the thoughts and actions of the individual. The natural endowment of the face is the result of hereditary influences, principally those of race and parentage. As the individual grows and develops after birth, the impress of thought, of action and of experience is made upon the countenance. The frequent use of certain of the muscles of expression, attendant upon the existence of some thought or emotion, cultivates a tonicity of those muscles, and develops folds in the integument of the face, which impart a certain cast or expression to the countenance. These two influences taken together, the one prenatal and determining the anatomical form of the features, the other postnatal and influencing the expression—establish the character and identity of a face. In discussing the human countenance Mantegazza gives five verdicts which may be taken upon it; physiological, ethnological, esthetic, moral and intellectual. The ethnological and esthetic are based solely upon anatomical characteristics, while the physiological, moral and intellectual are more largely founded upon expression. The term facial expression in its broadest sense is intended to include all the data upon which these several judgments are based. In this chapter it will be used with that meaning.

Facial expression is altered by the loss of the teeth and alveolar process in several ways:

1. Absence of the Teeth.—The teeth are displayed in the movements of the lip in laughing, in smiling and in speaking. Cigrand[1] says, "Artists tell us that when patients speak words as "at" or "ate" with the short or long sound of *a*, the lips should disclose about one-half of the labial surface of the anterior teeth, upper and lower, while with words having the long sound of *o*, as in "oral" or "open" the lips should hide the teeth to their edges." A larger proportion of the denture is displayed in smiling or in laughter. The relation of the lips and the anterior teeth during these acts constitutes one of their chief elements of beauty, and it is during their performance that a beautiful or unsightly denture imparts beauty or the reverse to the countenance.

2. Changes of Contour.—The alteration of the contour of the mouth and lips by the loss of the teeth is characteristic. While it is less marked in those of the lymphatic temperament whose short teeth and process underlie lips which are thick and sufficiently rigid to undergo little change after the teeth are lost, yet in certain temperaments where the lips are thin and require support from the teeth, the alteration in appearance is striking. The changes consist of alterations in the contours of the lips and in their relations. The lips fall inward instead of inclining outward as they do when supported by the teeth. The proportion of mucous membrane which is displayed is diminished. The line of separation between the lips, which may be an element of great beauty in a mouth, becomes changed, being altered in most instances from a graceful curve to a characterless straight line. The corners of the mouth, which are supported mainly by the canines, droop and an expression of weakness is imparted to the face. There is a disappearance of the sulcus mento-labialis, which is formed at the highest point of attachment of the soft tissues of the chin, when the lower lip is supported and slightly everted by the teeth (Figs. 53 and 55).

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[1] Facial Guide Lines as Taught by Artists and Sculptors; paper read before the Fourth International Dental Congress, 1904.

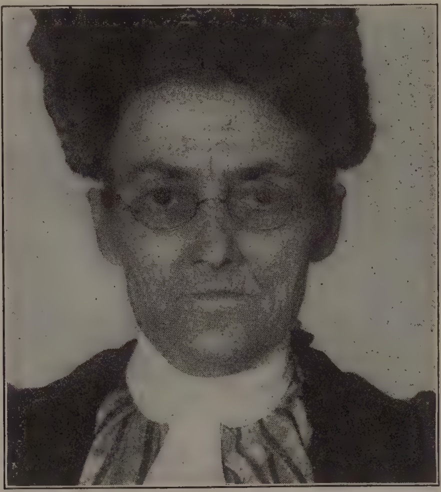

Fig. 52.—Photograph showing the wrinkles commonly observed in old age.

3. Changes in the Surface.—The changes which occur in the surface are the obliteration of some of the normal folds in the skin and the establishment of additional ones. Before discussing, however, those which result from the loss of the teeth, it will be necessary to point out those which result from old age, in order that no confusion between the two shall arise. The changes which ensue in old age are the result of two conditions: The resorption of the fat contained in the substance of the lips and cheeks, and the atrophic changes which occur in the skin. These result in the obliteration of contours at points supported by cushions of fat and in the establishment of wrinkles in the skin at points in the line of frequent muscular action. Normally there are masses of fat located in the hollow of the cheek around the buccinator and zygomatic muscles. There is usually also some beneath the levator labii superioris muscle and some at the symphysis of the lower jaw. These may be resorbed early in life because of defective nutri-

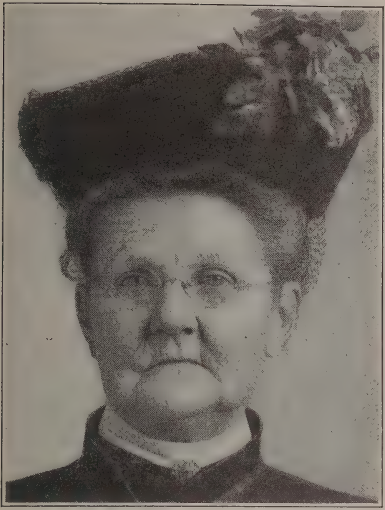

FIG. 53.—Photograph showing effect of the loss of the teeth upon the mouth, and the wrinkles established thereby.

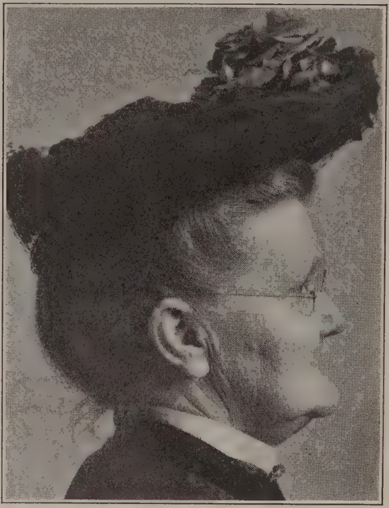

FIG. 54. — Photograph showing the effect of the loss of the teeth upon the profile.

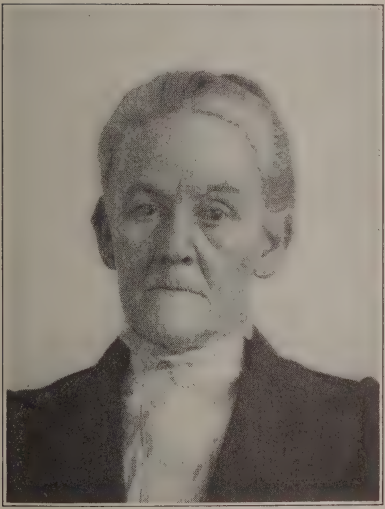

FIG. 55.—Photograph showing effect of the loss of the teeth. Front view of patient in Fig. 56.

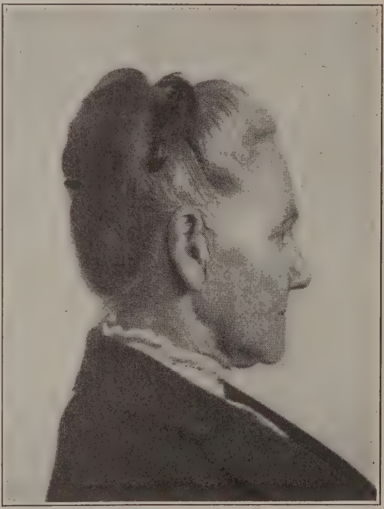

FIG. 56. — Photograph showing the effect of the loss of the teeth upon the profile.

tion. They are frequently resorbed after middle life in certain temperaments, notably the nervous. In the sanguine or lymphatic they are more likely to persist through old age.

In most individuals past forty years, wrinkles of the skin are apt to be established, although as is true in the case of the resorption of the fat, they are likely to appear earlier in a nervous face than in that of other temperaments. Camper has called attention to the fact that they are established at right angles to the line of muscular action. Those normally seen in an individual after forty years are the transverse wrinkles of the forehead, vertical wrinkles of the forehead, crow's feet or wrinkles at the external canthus of the eye, the naso-labial fold, which extends downward and outward into the cheek from the base of the ala of the nose, and the genio-mental wrinkles, extending from the cheeks to the chin (Fig. 52).

The loss of the teeth is followed by additional changes in the countenance. The naso-labial fold is accentuated, because the upper lip falls in, and frequently becomes two lines, one of which descends from the ala of the nose to the corner of the mouth (Fig. 53). The philtrum is usually obliterated (Fig. 55). This is due principally to the increase of the sphincter action of the orbicularis, which becomes necessary to keep the mouth closed in order to confine the saliva and food. Usually a groove is established extending from the corner of the mouth in the direction of the chin. In addition to these, small wrinkles placed radially to the oral orifice are established. While these last normally exist in some old people, they are much accentuated when teeth are lost because of the marked sphincter action of the orbicularis above alluded to.

4. Changes in the Relation of the Jaws. — The removal of the points of contact between the jaws results in their approximation. This is attended by a shortening of the soft tissues extending between the two; the muscles and connective tissues being actually decreased in length. As far as the lines of the face are concerned, this effect is particularly noticed in the decreased distance between the nose and the chin. In some instances this effect is marked, the nose and the chin coming so close together that a characteristic deformity is noticed.

5. Alteration of the Profile.—This is always changed to a greater or less extent. In those cases in which only a small amount of resorption of the alveolar process has occurred, there is only a flattening of the mouth (Fig. 56), while in others the falling in of the lips may be very marked (Fig. 54).

6. Alteration of Expression. — From what has been said concerning facial expression, or that which gives character and identity to the countenance, it must be seen that a condition which is succeeded by so pronounced a change in the features must greatly alter the characteristic expression of a face. One has but to remember the striking change in appearance which has followed the extraction of all of the teeth of an acquaintance to appreciate how marked an effect it has upon this means of identification.

CHAPTER II.

MOUTH EXAMINATIONS PRELIMINARY TO DENTURE CONSTRUCTION.

By EDWIN H. MAUK, D.D.S.

As the first step in the construction of artificial dentures, a careful examination of the mouth is required in order that the prosthetist may know the conditions to be encountered, favorable or otherwise, and estimate the success to be attained by taking advantage of the favorable conditions and modifying the unfavorable ones if possible. An examination is essential also for the formulation of an intelligent plan of procedure to determine the design of dentures, and as a basis for consultation with the patient as to the time and expense involved and the results to be expected.

Such an examination might well be termed a survey, since the making of dentures is so largely an engineering problem, aside from the esthetics and art principles involved. The essential features to be noted form a striking parallel to those in surveying, viz: the surface area, its boundaries, the nature of the surface, whether hard, soft, etc.; its topography, comprised in ridges, elevated points and depressions. Indeed the engineering point of view, under one name or another, and an analysis of the significance of these factors, are absolutely essential to the success of the dentures, whether retained by mechanical means or by so-called atmospheric pressure. This by no means implies neglect of the other elements concerned, such as the anatomy of the parts, their physiological function, and the pathological or other deviation of each from the normal. In other words, the prosthetist must be diagnostician, engineer, skilled technician and artist combined.

In order that the service to the patient may be rendered intelligently and efficiently, some systematic and orderly procedure in making the examinations should be adopted. Each operator will develop his own method of making the general examinations of the oral cavity including both the operative and prosthetic requirements, but it will be logical to take up the details of the survey for prosthesis somewhat in the order in which they present themselves, which will be to a great extent similar for all cases.

In any event, the survey should be completed by the formulation of a detailed plan of the work. In the case of partial dentures, this may require the making of impressions and study casts since these cases present so many factors not involved in the construction of full dentures.

Age and Physical Condition of Patient.—The general physical condition and comparative age of the patient are among the first things to be noted, as they are often directly related. With patients of advanced age and broken health, or with some marked physical infirmity, the degree of success attainable, especially with dentures worn for the first time, is problematical, since the patient may find their presence a disturbing element and the effort to become accustomed to their use too great a burden for declining energies. In such cases the patient is often unwisely advised to procure dentures, urged perhaps by members of the family in a mistaken estimate of the probable benefit to be derived therefrom. When such a patient presents, especially after being without teeth for a considerable period of time, and with evident lack of tone of the oral muscles and tissues, it often becomes the duty of the prosthetist to decline the case as tactfully as possible, while making clear to the family that it is better to spare the patient what may be a real ordeal without any definite assurance of success in the end.

Mental Attitude.—During the examination the patient's mental attitude regarding artificial dentures is usually made apparent and is an extremely important factor. One who has a pronounced prejudice against "false teeth" presents a problem matched only, perhaps, by the one who expects them to equal or surpass those provided by Nature. The patient who has worn artificial dentures; who appreciates and has overcome the difficulties incident thereto, will usually coöperate with the prosthetist to the best advantage.

In this connection, it should be ascertained what quality is most desired in the dentures. Only too often, the patient's dominant thought is of appearance only, and efficiency is lost sight of. Others demand only efficiency and comfort, and have no appreciation of artistic results. In order to reconcile these inconsistenceis the prosthetist must know the patient's point of view; perhaps it will be volunteered or indicated by chance remarks, during the examination, or may have to be elicited by questions.

Seating Patient: Instruments.—It is assumed that the patient will be comfortably seated in the dental chair, suitable protection provided for the clothing, and a few necessary articles at hand, including a mouth mirror, cotton and cotton-pliers, a blunt probe, an instrument with a large ball end, an explorer, and some small towels or napkins in which to receive and hold dentures which the patient may be wearing, during their removal for examination and discussion.

Edentulous or Partial Case.—The existence of remaining natural teeth in both jaws, or an entirely edentulous condition is soon disclosed, or one in which one jaw is edentulous with some natural teeth present in the other. The examination of the totally edentulous condition will be simpler and will proceed along somewhat different lines from either of the other two, but will have details common to all.

Edentulous Mouth.—In looking into the mouth it will be necessary to consider certain features of both upper and lower jaws and then to proceed to observe details of each separately. The condition of the alveolar ridges as to the amount of resorption which has taken place claims attention immediately, and only a considerable amount of practical experience or familiarity with these conditions gained by study of typical casts can afford a basis of good judgment as to what would be a favorable bulk in this region for a given case. In the lower jaw especially, it is most desirable to have a comparatively full, well-rounded ridge of good height as the principal contributing factor to the success of the lower denture. In connection with the bulk of the ridge, observation must also be made of its symmetry and evenness of outline, as it is evident that fitting a denture will be much more difficult on a ridge with alternating depressions and protuberances than on one with a comparatively even surface. Closely related to this is also the question of fulness, especially of the upper jaw in the anterior region under the lip, where too great a prominence will leave so little room for the necessary thickness of the denture as to cause an unnatural bulging of the lip. For this reason the height and fulness of the upper ridge should be specifically compared to the length of the upper lip, and in some cases where a marked disproportion exists, it will be advisable to recommend the surgical removal of the excessive alveolar process before attempting to make the denture.

Relation of Jaws.—Another condition to be noted at this time is the relation of the jaws to each other antero-posteriorly and at the region of the tuberosity of the upper on both sides. A very convenient method of ascertaining this is to interpose as much of the end of the finger or thumb as will correspond to some extent to the combined length of upper and lower central incisor crowns, between the jaws at the median line and to ask the patient to close to that extent. In this position the antero-posterior relation may be readily observed by looking at the patient's profile while holding the lips back slightly, and if either the upper or lower protrudes markedly with reference to the other, difficulty will be experienced in the arrangement of the teeth with regard to appearance and stability of the dentures. The condition at the tuberosities can be seen with the aid of the mouth mirror.

If the tuberosity of the upper jaw is seen to be in too close proximity to the ramus of the lower, there may not be room for the combined thickness of the two base-plates in that region. This condition sometimes results when thick masses of alveolar process have surrounded the molar teeth and, not having been removed at the time of extraction, persist in this location without being resorbed. In some instances these masses are so bulky as to present very pronounced projections on the buccal surface, which interfere with the removal of the impression, and may make it impossible to insert the denture without severely abrading the surface tissues. When such a condition is revealed by the examination, surgical removal of the process is indicated prior to taking an impression.

When the lower posterior teeth have been extracted for a period of some years before the removal of the uppers, and no artificial lower substitute has been worn, the posterior upper teeth, together with the alveolar process surrounding them, almost invariably appear to have moved toward the lower jaw. If these teeth are then removed in preparation for a denture, without also removing a sufficient amount of the process surrounding them, the condition described above is sure to result.

Relative Sizes of Arches.—The relative sizes of the two arches[1] should be noted while determining their relations. While good stability and retention of the dentures is largely dependent upon and proportionate to the area covered, and therefore large arches are favorable in this respect, a large lower arch and a small upper will cause difficulties in tooth arrangement in the molar region as well as in the anterior; a large upper with a small lower presents a problem even more difficult.

It is quite usual to find the width of the upper arch at the tuberosities considerably less than that of the lower in the corresponding region. This is due to the fact that resorption takes place after extraction in the upper jaw principally at the expense of the outer and thinner plate of bone, while the reverse condition is true in the lower because of the heavy mass of bone external to the molar teeth at the base of the ascending ramus.

Mandibular Movements.—Another factor which suggests itself at this juncture is the range of movement exhibited by the mandible. For reasons which are not entirely clear, but presumably have to do with the irregular loss of the teeth on one side or the other of one or both jaws, lateral movements of the mandible which are extremely important in mastication, seem to become restricted, in some cases so that they are almost entirely lost. In other instances, while it may be possible for the patient to produce all the habitual movements of mastication, definite control of them seems to be lacking. Either of these conditions is likely to limit the efficiency of the dentures in mastication.

After the above general observations have been made and noted, attention will naturally be directed to more specific details, some of which are to be found in both the upper and lower jaws, while others are characteristic of one jaw only.

Fibrous Bands.—The point of attachment of fibrous bands of tissue at several locations along the external surfaces of the ridges, particularly those in the region of the bicuspids in both upper and lower jaws, and at the median line in the upper, is of much importance. If these bands are tense or attached near the summit of the ridge, careful provision must be made for them along the periphery of the denture, especially the lower so that they will have sufficient unrestricted movement to avoid irritation, and will not dislodge the denture from its normal position in speech or in the ordinary movements of mastication. In some cases it will be necessary to divide such a band at the ridge by a slight surgical operation, and prevent its reattachment by inserting a temporary base-plate with the rim extended, or by means of cauterants.

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[1] The word arch is here used in the same sense as in describing the teeth of one jaw as a group, referring to their approximation in a curved row, the ridge left after their extraction conforming in a general way to the original curve. This should not in any way be confused with the curved roof of the mouth, this being termed the vault, or the palatine arch.

Any pathological conditions of the tissue surfaces within the denture area are usually quite evident by their appearance; redness, small eruptive papules, abraded or eroded spots or a puffy appearance are all indications of abnormality. The presence of lues should be watched for by the operator, and any symptoms of its existence in the oral mucous tissues justify a searching inquiry, and a resort to the usual tests if necessary to complete the diagnosis.

Soft and Hard Areas.—The density of the submucous tissues and their thickness, together with a differentiation of soft and hard areas, pendulous masses in the upper, or a flabby ridge crest, should be established by a digital examination. Considerable pressure with the end of the finger along the summit of the alveolar ridges and over the entire vault in the upper jaw, then following more particularly in the vault with the ball-ended instrument will give the necessary information. Flabby areas are likely to be found along the ridges, most frequently in the anterior region of the upper jaw; occasionally a pendulous mass of mobile tissue is found in the region of the six upper anterior teeth, or similar masses may occupy the area of the tuberosity on one or both sides of the upper jaw. If these masses are small, the denture can usually be made to cover them with a fair degree of success.

If they are large and freely mobile, their surgical removal is indicated, otherwise the denture will be movable in a proportionate degree, and although it may be retained moderately well, it will afford little service in mastication owing to its lack of support.

Smooth, rounded or elongated bony growths occur not infrequently along the hard palate in the median line, and more rarely, knobby, hard masses stand out from the surrounding surface at this location and are readily evident by their size and prominence.

In an extreme case such a growth requires surgical removal. If the growth is small its presence will probably not interfere materially with the denture, but provision must be made to relieve the pressure of the denture on it either by scraping the impression or by building up this area on the cast.

Pressure Relief.—It is necessary to provide for relief in the palatal area in virtually all upper cases and in lower cases when the summit of the ridge is thin and sharp, either by scraping the impression before making the cast, or by building up the cast itself with tinfoil as directed in the chapter on Casts and Models.

When making the examination it is well to determine the extent of the hard areas which will need relief. In the lower jaw this will be evident by the shape and size of the ridge, but in the upper jaw it can be definitely located only by testing with the end of the finger and with the ball-ended instrument using considerable pressure. By noting the extent to which the tissues are indented, and testing the whole area of the vault at close intervals, soft areas will be differentiated from the hard, and their respective boundaries defined with sufficient exactness to be a reliable guide for the scraping. The hard area will usually be found most distinctly along or bordering on the median line, and when the impression is taken, it is well to sketch on it immediately the relief areas, and verify their extent and location by the use of the round-ended instrument again.

Gagging.—While making the digital examination above referred to and continuing it with an instrument, it is frequently found that the soft palate in the region of the uvula, and in some cases a zone extending across the posterior part of the vault for some distance in front of the uvula, are so highly sensitive that when the surface is touched with an instrument or the finger, the patient is nauseated and "gags," as it is termed, making a convulsive effort such as precedes vomiting. This may be mild and is overcome as manipulation of the parts proceeds, or may be controlled by the patient to a certain extent. In some aggravated cases this condition is so distressing and persistent that it becomes impossible to secure an impression without preliminary treatment, or if the impression is successfully taken, the finished denture may continue to cause the same symptoms to an unbearable degree. When this happens, the patient invariably wants the denture trimmed, which, if done freely enough to stop the gagging, may reduce the surface which the denture covers so much that it will no longer be retained successfully. To provide against this contingency, when such a condition is revealed during the examination, it is well to plan the denture so that its posterior border will lie on the zone of tissue just back of the hard palate, where it is found to yield readily under pressure (but not to extend it so far as to rest on the tissues which move in swallowing or speaking) and to make it bear with more than ordinary pressure along its posterior edge by scraping the cast in the corresponding position. This has been found quite effective in many cases, for which the explanation is given that if these sensitive tissues are allowed to merely touch the plate edge or to vibrate against it, the effect is analogous to that of tickling, but if a pronounced pressure is produced the sensation is recognized as such, without the unpleasant symptoms.

Measures to Overcome Gagging.—To control the nausea during the impression taking many remedies have been suggested and tried with varying degrees of success. Sometimes it is sufficient to swab the sensitive area with some agent having a mild anesthetic or refrigerant effect. The solution containing menthol, thymol and phenol prepared for medication of carious cavities has been used with success in diluted form to avoid the escharotic effect of the phenol. The use of the preparations known as phenol sodique and campho-phenique has also been reported as successful. In aggravated cases, the use of cocain solutions swabbed on the surface, in a concentration of from 1 to 5 per cent, has been suggested, but these must be used in very limited quantity and with great care to avoid their passing into the throat and producing anesthesia over a much larger area than is intended. It has also been suggested that injections of novocain be made at the posterior palatine foramina, but this is open to the objection that the tissues are thus distended so that the impression does not represent them in their normal condition.

Partial Cases.—It will be recognized that many of the above observations apply to the examination of cases where some teeth remain as well as to edentulous ones, but the former group presents many additional features not involved in the latter. First attention is claimed by the number of teeth present and their arrangement with reference to the spaces. Mathematical computation has shown that a tremendous number of combinations are possible, running up into many thousands, but for the purposes of diagnosis and with reference to the principles and details of construction, these may be grouped into a comparatively small number of classes which are more appropriately taken up as details of making the dentures.

The condition presenting the most troublesome problems and the least prospect of a successful denture is that of narrow spaces left by the loss of a single tooth or two teeth, closely alternating around the arch with remaining teeth standing alone or in small groups of three or less. The spaces, in such a case, usually present undercuts, and if the teeth have been out for any length of time, are usually constricted to such an extent that there is not sufficient room for the insertion of artificial teeth of the proper size. On the other hand, spaces of considerable length with firm, sound teeth at each end are much more favorable for the construction of dentures which will give both comfort and efficiency, especially if the spaces are at relatively opposite points in the arch, establishing a sort of balance.

Retention, Partial Dentures.—The problem of retention for partial dentures is quite different from that of full dentures, depending very largely upon the use that may be made of the remaining teeth for this purpose through the medium of clasps or devices having the same function as clasps, so that the condition of the individual teeth at the ends of spaces where such retention devices are applied by preference or necessity, requires careful scrutiny to determine their fitness for such use. If these teeth are sound and of normal contour, with their long axes normally inclined to the arch or nearly so—in other words, if in a condition which closely approaches normal—they need give no further concern at this time, and the examination may proceed to other details. An isolated tooth, a molar for instance at the posterior end of a space, is frequently valuable for purposes of retention, but more often, in other parts of the arch, is of little or no value for this purpose, and may constitute a distinct obstacle and detriment in the construction of the denture.

An instance of this is afforded in the case of a single tooth, or even a small group of teeth in the anterior region. Though often considered by the patient as of great importance and value for appearance it will be found extremely difficult to align the artificial teeth with them, or to match their color and shape, so that the result is conspicuously inharmonious in appearance, and retention is seriously interfered with by the presence of the teeth.

If the remaining teeth, not only those at the ends of spaces, but all that are present in the arch are not in a normal condition, which is seldom the case, especial attention must be directed to the question of their value, and it should be decided at this time whether they shall be retained or extracted, or the completion of the plan for the denture should be deferred until this question can be decided after treatment of the teeth of doubtful status, or after further examination of their possibilities by means of radiograms. These teeth may be the ones most needed for the support of the denture, and to have the necessity for their removal become apparent when the plate is partly completed, may change the entire plan and involve the reconstruction of what has already been done.

Necessity for Extraction.—Various degrees of deviation from the normal will be found to exist with regard to the teeth in question, but two especially claim thorough attention and careful estimate of the possibilities involved before making the decision as to extraction or retention, namely, badly broken-down crowns, or those with extensive restorations, either by fillings or artificial crowns, and pulpless teeth, or roots. With regard to the first, it will be necessary to judge whether their crowns can be restored successfully by crowning operations or otherwise, or whether the restorations already made are successful in restoring the tooth to usefulness and properly designed and constructed to prevent recurrence of decay or injury to the supporting tissues. This applies particularly to those to be used for the support of the denture.

The second condition, that of a tooth or root without a pulp, does not necessarily condemn the tooth to extraction. Though it is recognized that a pulpless condition is far from normal and that such a tooth is of doubtful value as compared with a similar tooth having a living pulp, it is nevertheless true that it can often be made to serve a most useful purpose and perform its function in a perfectly satisfactory manner for an indefinite period of time, when the details of root medication, root filling and crown restoration have been carried out in accordance with well-established principles of technic for such work.

Pulpless teeth found to have marked pathological conditions affecting the peridental membrane or the apical region, resulting in destruction of the membrane and pronounced loosening of the teeth, or the condition known as apical abscess, should not be considered as prospective supporting units for a denture since the additional stress imposed would strongly tend to reinvolve them even after apparently successful treatment.

Gingival Irritation.—The gums surrounding the teeth must be carefully examined for evidences of irritation resulting from deposits of calculus, as well as the roots of the teeth themselves, to disclose the possible existence of such deposits. These if present must be removed prior to the taking of the impression, otherwise the fit of the denture at such points will be defective, and the irritation not only will be perpetuated and aggravated, but may prevent entirely the wearing of the denture. The retention of teeth affected to any marked extent by so-called pyorrhea is always doubtful. If in the judgment of the operator, or as indicated by the past history of the case, the condition cannot reasonably be expected to clear up under treatment, early extraction is indicated.

The general condition of the gum tissues, as referred to under the discussion of examination of edentulous mouths, should not be neglected for partial cases, and when the denture is to cover the roof of the mouth, similar provisions should be made for relief of the hard central area, since the partial denture is likely to "settle" and rock to an even greater extent then the full denture unless it is wholly supported by the remaining natural teeth.

Vertical Space Available.—A careful examination should be made as to the distance between ridge portions of the upper and lower jaws where teeth are to be supplied, or between the ridge of one and the opposing teeth of the other. Frequently as the result of a long interval elapsing after the extraction of part of the teeth of one jaw, without dentures being supplied, the opposing teeth become greatly elongated, so that the space is partly or almost wholly taken up when the teeth are in occlusion. It is not infrequent to find these elongated teeth touching the opposite gums in the masticating position, which of course makes the insertion of a denture impossible, and leaves no choice but the extraction of the elongated teeth.

Usually these teeth have become loosened as well as elongated so that they would not be valuable in mastication even if it were possible to retain them.

In other instances of the same character, when the teeth are only slightly elongated, it may be possible to gain sufficient space for the insertion of the artificial teeth by grinding off a certain part of their occlusal surfaces, which may also be desirable to improve the alignment and relative length of individual cusps. In fact, the inspection of the cusps and incisal edges of all the remaining teeth should be one of the features of the examination. In the anterior region especially, the appearance is often marred by a series of jagged edges, and the patient must be informed of the necessity for trimming these to facilitate the arrangement of the teeth which are to oppose them as well as in the interest of good occlusion and articulation. This can be taken up more fully under the details of constructing the dentures.

Color of the Remaining Teeth.—The color of the remaining teeth in the anterior part of the mouth, if they are to be approximated or opposed by artificial teeth, merits some attention during the examination, together with their length and shape. Upon these details depend in large measure the artistic and harmonious effect of the denture, and although more thorough consideration can and should be given to this item at a later stage of the work, the patient may have some useful ideas on these points which should be ascertained by the operator.

Records.—Although some prosthetists keep careful records of the data collected during the examination for dentures, together with the recommendations made, details of treatment necessary, estimate of cost and a tentative plan of the work with salient details noted, this is often neglected. Such a record is of great importance in avoiding future misunderstandings and for the guidance of the operator when the time comes to make the dentures, as a considerable interval may elaspse between the time of the examination and the beginning of the work. For the best interests of all concerned, such a record should invariably be made and carefully filed, so that it may be readily referred to at future visits of the patient or when otherwise needed in determining details of the construction of the denture itself.

With a careful examination covering the features outlined for edentulous or partial cases completed with the record just referred to, the patient may be provided with an appointment for a future date and dismissed, or the first stage of denture construction or any necessary preliminary treatment may proceed at once.

For the convenience of the student, the following brief guides embodying the salient features in making examinations preliminary to denture construction have been prepared. They are not intended to be exhaustive nor arbitrary as to the sequence to be followed, but have been arranged with considerable thought as to the manner in which the various points enumerated logically present themselves for consideration.

Examination Guides.

General Considerations.

- Age of patient.
- General physical condition.
- General mental condition.
- Mental attitude regarding dentures.
- Edentulous or partially so.
- Profile and contour of features.
- "Tone" of facial tissues, and general appearance (wrinkles, folds, sagginess, etc.).

Edentulous Mouth.
- Surface conditions of tissues, pathological conditions, or surface abrasions.
- Amount of resorption of ridges, height, thickness, sharp edges or spines.
- Symmetry of ridges.
- Fulness of anterior region.
- Fulness of other parts.
- Relation of ridges, antero-posteriorly and vertically.
- Space between ridges, especially at tuberosities.
- Relative sizes of arches, upper and lower.
- Shape of arch and shape of vault.
- Tissue attachments to ridges.
- Undercuts and projections.
- Density of tissues:
  - Hard and soft areas.
  - Abnormal growths.
  - Pendulous masses.
  - Flabby ridge areas.
- Mandibular movements:
  - Freedom of.
  - Control of.

Partial Cases.
- Number of teeth remaining.
- Position of teeth relative to spaces.
- Size of spaces.
- Inclination of teeth at ends of spaces.
- Presence and position of teeth suitable for clasps or similar devices.
- Space vertically between ridges.
- Space vertically between ridge and opposing teeth.
- Nature of occlusion.
- Surface condition of tissues (same as edentulous).
- Condition of individual teeth:
  - Crowns; carious, broken-down, restored.
  - Pulpless or vital.
  - Pathological conditions, pulp canal.
  - Pathological conditions, apical region.
  - Pathological conditions, peridental membrane.
  - Deposits of salivary calculus.
  - Teeth elongated, tipped, rotated, loose.
  - Color, size, shape of remaining teeth.
- Records of conditions found by examination.
- Plan of dentures in accordance with conditions found by examination.

A Guide for Detailed Examination or Survey of the Edentulous Patient for Full Dentures.—This includes the specific items for observance and notation, and the sequence of procedure for both visual and digital examination. The survey is principally visual, supplemented by digital examination at certain stages or followed by the digital in the order given below, together with conversation and questions to bring out details not otherwise revealed.

General Considerations.

Age of patient.
General physical condition.
General mental condition.
Mental attitude regarding dentures.
Economic conditions and financial arrangements.

Seating of the Patient.—Seat the patient as in an ordinary chair, with the body, shoulders and head inclined slightly backward from the vertical, and the head supported by the headrest. Do not tip the head backward so that the patient is looking upward. This cramps the muscles of the neck and lower jaw, and puts the head and face in an unnatural aspect and out of proportion when viewed with the rest of the body.

Visual Examination, External Appearance.— *Note four items:* Full front view, profile view, fulness or contour of lips and condition of facial tissues (such as wrinkles, folds, sagginess).

Visual Examination, Upper Part of the Interior of the Mouth.—Do not ask the patient to open the mouth, but insert the two index fingers and draw the lips upward and outward at the angles of the mouth, thus affording a view of the anterior portion of the upper ridge. *Note three items:* Tissue attachments (especially the labial frenum) the labial contour of the ridge, the contour and length of the ridge taken together in relation to the length of the upper lip.

Now have the patient tip the head slightly backward, thus bringing into view the arch and vault as a whole. *Note eleven items:* Apparent tone of the tissues, the form of the vault, abnormal ridges or lumps in the vault, the form of the arch, the size of the arch, the form of the ridge, the thickness or bulk of the ridge, any sharp points or eminences on the ridge, position of the tuberosities, the fibrous tissue attachments at the posterior portions of the tuberosities.

Next with one index finger at a time expose each vestibular space separately in turn. *Note three items:* Buccal projection of tuberosity or undercut, the size of the vestibular space and position of the buccal tissue attachments.

Visual Examination, Lower Part of the Interior of the Mouth.—Direct the patient to resume the erect position of the head, again insert the two index fingers and draw the lips downward and outward at the angles of the mouth to bring the lower ridge into view. *Note seven items:* Tissue tone, the form of the arch, the size of the arch, the form of the ridge, with especial attention to the distal termination, as to whether it is lumpy or smooth in this area, the size of the ridge, the buccal tissue attachments, which are frequently held down tightly by adhesions remaining after extraction, and the amount of the vestibular space.

Now bring the fingers more toward the front and hold down the lip, exposing the anterior part of the ridge to view. *Note two items:* All tissue attachments to the base of the ridge, and any undercuts that may be present. Direct the patient to lift the tongue slightly toward the vault and note all the lingual muscle and tissue attachments.

Digital Examination.—Digital examination either in conjunction with or following the visual.

Upper part of the mouth: Palpate the entire upper ridge and vault for six items: The location of hard and soft areas, tender spots, flabby spots, undercuts at tuberosities on buccal surfaces, the extent of cartilaginous tissue at the posterior border of the hard palate, and the tendency to gag as this region is touched by the finger.

Lower part of the mouth: Palpate the lower ridge in the same manner as directed for the upper for five items: Hard and soft areas along the ridge, flabby tissue masses at the distal terminations of the ridge, spinous bony structure along the summit of the ridge, the prominence and position of the mylohyoid ridge relative to the summit of the alveolar ridge in that region, and the tendency to gag when palpating the disto-lingual area.

As a final item in the digital examination, prop the jaws open with a finger or fingers so that they will be separated about 20 to 25 mm., draw the lips aside and note the relative positions of the upper and lower ridges in the anterior region.

CHAPTER III.

IMPRESSIONS OF THE MOUTH.

By EDWIN H. MAUK, D.D.S.

After the examination or survey of the mouth has been completed, the next step in the production of a prosthetic appliance incorporating a base-plate is to secure a tangible counterpart, an accurate reproduction of the parts for which the appliance is to be made, and upon which the work may be done.

In order to do this, it is necessary to have an imprint of the parts, which obviously must be made in some plastic material. This is known as the impression, and the process is referred to as "taking the impression."

THE IMPRESSION.

An impression may be defined as a *negative* imprint or likeness of the parts, from which the *positive* or cast is to be made.[1]

In the examination or survey of the mouth preliminary to restoring a number of lost teeth by means of a prosthetic appliance, the plan or design of the appliance and the means of its retention are determined in conformity with the data thus obtained. If the restoration is to be of the bridgework type depending upon remaining teeth as abutments for retention, the preparation of the abutments for the anchorage device may demand attention first, the impression being more or less incidental to establishing the position of the abutments on the model.

This is also true to a certain extent of partial base-plate dentures retained by frictional anchorage devices, but the general principles of impression taking apply to both of the foregoing as well as to artificial dentures supplying all the teeth, and the student can readily make the application where it is not specifically described in the following pages.

The *requisites of a good impression* for an artificial denture are: (1) That it shall accurately reproduce in detail the parts of the jaw. This is subject to exceptions, since it is desirable at times to have an imprint of certain tissues as they are modified by muscular action or as they may be modified by the action of the impression material itself. (2) That it shall cover all the area which it is intended to include in the finished plate, if possible, and no more. This applies particularly to full denture impressions, and is not always attainable in the case of partial denture impressions. (3) That its edges, which will determine the periphery of the finished denture, shall be rounded and sufficiently thickened to properly fill the *cul-de-sac* between the tissues of the cheek or the tongue, and the base of the alveolar ridge, in order that similar edges may be reproduced accurately on the model, and finally upon the finished denture, in such a manner as to aid retention and avoid irritation to the tissues.

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[1] A nice distinction should be made between the terms "cast" and "model." The object produced by filling or pouring or "casting" an impression is always a cast. As soon as it is put into use as a surface on which to shape a part of the appliance being made or when used as a pattern for molding, it becomes a model. This has resulted in the loose usage of the words by the dental profession, since casts almost invariably are put to use as models, except when preserved for study or record purposes.

The results which are sought in denture making are comfort, efficiency and good appearance. Of these the first two are more dependent upon the ultimate perfect adaptation of the denture than upon any other single factor, and this in turn is almost solely dependent upon the accuracy of the impression.

Accuracy.—To be accurate in the sense here intended, an impression must not only copy fine lines and other features of the surface, which is an essential required of the impression material itself, but must also faithfully portray the living tissues in the physical or functional condition most favorable to the success of the denture, an essential largely within the control of the operator, especially if he is aided by the patient under direction. Thus it is possible to take an impression of the lower edentulous jaw, for instance, which will be an accurate reproduction of the surface in every minute detail, but will represent the fibrous and muscular attachments at the base of the ridge in a passive or displaced condition, which would be fatal to the stability of the finished denture with these attachments in the active state. Another impression may be made with the same material, equally accurate in the surface detail, but representing the attachments approximately as they function during the use of the denture, obviously a condition more favorable to its success. Again, an impression may be made of the upper edentulous jaw having considerable pendulous or flabby tissue, especially along the ridge, with this tissue in its pendent position, or the same tissue may be represented in another impression approximately as it will appear when compressed by the denture during the act of mastication.

It is evident then, that control of the impression material and the ability of the operator to utilize its possibilities are as essential to the accuracy of the impression as any physical characteristic of the material itself.

Area Included by the Base-plate.—It has come to be recognized as one of the essentials in modern denture making, that the base-plate shall cover as much area as possible with no discomfort to the patient, or undesirable alteration of the facial contours, in order to utilize the tissues upon which it rests to the fullest extent for the purposes of retention of the substitute and resistance to masticatory stress. This will be discussed more fully under Principles of Retention in Chapter VI.

There are also reasons connected with the technical processes of making the denture which make it desirable that the area to be covered by the denture shall be established at the time of taking the impression, and definitely determined by the impression itself.

To have an impression cover a larger area than that of the proposed denture, creates considerable doubt and uncertainty in finally establishing the peripheral outline of the latter on the cast. To have it cover an insufficient area necessitates carving the cast to extend the peripheral borders of the denture, which is largely guess work, or if this is not done, it leaves the denture deficient along the rim so that its stability and retention are likely to be impaired.

Edges.—An impression with the edges trimmed or filled out, as may be necessary, to a thickness appropriate for each part of the mouth upon which its periphery lies, and with the borders rounded so that they conform to the curve of the tissues as they merge with the cheek or the floor of the mouth at the base of the ridge, may be tested in the mouth when finished. It will thus afford a fairly reliable forecast of the comfort and stability of the finished denture, as well as of its ultimate effect on the facial contour. These edges will then be automatically reproduced on the cast and also on the finished denture in the case of vulcanite, while with a metal denture they will serve as an accurate guide for the shaping of the rim upon dies, or of the wax pattern when the plate is to be cast. Such a denture because of its rounded edges reduces the possibility of irritation of the tissues to the minimum, and therefore usually requires little or no trimming to relieve such a condition.

It is true that to obtain impressions with the requisite qualities above mentioned materially increases the time and effort required in the operation itself, but the results more than justify such expenditure. It must also be evident that, to obtain such results, a suitable choice must be made of the available materials and that their good qualities must be utilized to the fullest extent and their inherent defects overcome by manipulation based on a thorough knowledge of their physical behavior and the chemical phenomena upon which it depends.

Impression Materials.—The choice of impression materials is necessarily quite limited. The ideal impression material has not been found, and probably will not be, unless some synthetic combination is made incorporating all the qualities desired in one substance. Certain materials are available, however, combining enough desirable qualities to approach the ideal. By taking advantage of these characteristics, and by adopting a technic in which they are best utilized, but in which their limitations are recognized, most excellent and satisfactory results are attained with such materials in the production of impressions and the subsequent steps dependent thereon in the making of dentures.

The qualities that an impression material should possess are:

1. It should be agreeable to the patient in color, taste, odor and consistency.

2. It must not injure the oral tissues in any manner.
3. Its maximum plasticity should lie within a temperature range of heat and cold readily tolerated without discomfort in the mouth.
4. It should copy fine details of the surface accurately, and retain its form without distortion when removed from the mouth; therefore it should be inelastic.
5. It should pass from the plastic to the rigid state promptly, yet allow sufficient time for manipulation.
6. It should neither contract, expand, nor warp in the rigid state at ordinary room temperatures.
7. Its preparation and manipulation should be easy with simple equipment.
8. It should be free from deterioration, so that its working qualities are constant.

No substances are known which in their native state possess enough of the above qualities to be desirable for the purposes of impression taking, but a suitable material must be prepared for use by appropriate processes or by combination with other substances. Two materials only have been produced which sufficiently answer the requirements so that they have continued in general use, and these differ widely in their physical characteristics, their chemistry and their manipulation. They are, in the order of the length of time they have been in use: *Plaster of Paris* and *modeling compound*, or *modeling composition* as it is frequently known.

Plaster of Paris owes its name to the fact of its early production in large quantities in the outskirts (at that time) of Paris. Its use in dentistry was adapted from the arts and crafts, and it continues to be used in great quantities as a building material, the commercial grades for that purpose differing from dental plaster in their texture and purity. It is commonly referred to simply as plaster, and will thus be mentioned in these pages.

Self-separating plaster is a name given to a mixture of starch with plaster which, when incorporated with water and set in the usual manner, has the property of disintegrating in hot water. Its use is confined to impression work, and its advantage lies in the fact that it may be separated from the cast merely by immersing in cold water and heating to the boiling point, thus avoiding the usual cutting and chipping of the impression and the liability of mutilating the cast thereby. The following formula may be considered typical of these mixtures, several brands of which are on the market:[1]

Impression plaster	3 parts
Potato flour	1 part

Coloring matter in the form of a dry pigment is added in some instances.

Modeling compound of the varieties most used at present is produced especially for dental purposes, quite aside from any application it may have had in its original form in the arts and crafts. Its use in dentistry being confined principally to taking impressions, its original designation as "modeling" compound has been superseded, and it is now commonly referred to as compound, and the impressions made with it as compound impressions.

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[1] Dental Cosmos.

Wax, principally of the variety produced by bees, formerly extensively used for impressions and sufficiently accurate for that purpose when dentures were held in place by reciprocating coiled springs rather than by "suction," has been displaced by plaster and compound.[1]

Compound can also be more conveniently and readily used for building up parts of impression trays, for which wax is often used, and, in fact, an entire tray may be fashioned from it, for which express purpose one variety has been produced and is offered in the market. Compounds of various waxes are still indispensable in dentistry in making patterns for castings and as a base for the arrangement of teeth for dentures, both of which are described elsewhere in this text.

Gutta-percha, a vegetable substance derived from the juice of a tree, the *isonandra gutta,* formerly used for impressions to some extent, has likewise been displaced by compound, because of the superior working qualities and convenience of the latter.

The very marked increase in the use of compound for impressions which has taken place in recent years has been accompanied by many variations in technic, especially for edentulous impressions, and much diversity of opinion exists regarding its comparative value for this purpose. Some have favored the use of compound for all impressions; some, the exclusive use of plaster, and others, combinations of the two, such as, a compound impression finished with plaster, or a tray of compound used merely as a base for an impression which is completed by several successive additions of plaster. For the latter it is claimed that perfect adaptation is thus secured without tissue displacement.

Some have also advocated the rather anomalous procedure of the "closed mouth" impression, claiming for it perfect surface adaptation and equalized pressure under masticating stress with an accurately corrected periphery which, being shaped by the action of the patient's muscles, allows them free play during mastication without displacing the denture. This, of course, represents only one phase of the muscle activity which affects the stability of full dentures. Likewise, dependence upon the muscle movements of the patient to establish the periphery of a compound impression is attended with considerable uncertainty, since many patients who are most in need of dentures have deficient muscular control or will not coöperate fully with the prosthetist in this feature of the work.

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[1] In this connection a reminiscence by the late L. P. Haskell is of historic interest. He stated in the writer's presence that the first use of plaster for impression taking was by his brother-in-law, Hansen, of Boston, in 1844, and that previous to that time dentures were maintained in position principally by means of coiled springs, no adhesion being expected by patient or operator. Also that in his presence and that of several other dentists invited for the occasion, a test of one of the first dentures made from a plaster impression, a full upper gold-swaged plate, consisted of suspending a bucket of water from a hook in the center of the plate—to the great astonishment of those present.

Much stress has been laid upon the ability of compound to compress the soft tissues during impression taking in order to secure equalized bearing of the dentures upon soft and hard tissues alike. It is doubtful if this property can be controlled and directed with sufficient certainty to place any dependence upon it. Compound is virtually inelastic, and its ability to copy details is dependent upon this quality together with its softness at the time of receiving the imprint of the object being copied. If used soft enough to copy fine detail in the mouth, it will not compress the tissues except momentarily at the instant of application, and the soft tissues being elastic, will react against the compound and neutralize the compression before the compound is set or cooled enough to hold the tissues compressed.

It seems to be apparent that the effect of equalized bearing on hard and soft areas may be more effectively produced by the intelligent application of the plaster finish than by compound alone, especially in upper impressions where the equalization effect is most sought. Thinly mixed plaster obeys the laws of hydraulics and is incompressible in any ordinary manipulations. When confined under pressure in a compound impression with a closely adapted periphery (virtually a cup), it flows to the areas of least resistance, *i. e.*, the softer parts. Being incompressible itself, it tends to slightly displace the yielding tissues by compressing them, and remains there until crystallized. This is made evident by examination of such an impression when removed from the mouth. Invariably there are shown patches of plaster of unequal thickness corresponding to soft areas alternating with bare spots of compound where the plaster has been displaced entirely by the harder parts.

In the various methods advocated for full denture impressions, the objects sought are virtually the same, namely, correct surface adaptation with equalized bearing pressure, and the establishment of a definite peripheral limit, including the largest area possible for the denture base without causing any discomfort to the patient. The most valuable quality of compound which recommends it for this purpose is the fact that it can be so readily trimmed, modified and readapted to correct the peripheral outline and other essentials of the impression. Its tendency to form wrinkles and folds and to become distorted in the process of readaptation is compensated for by the plaster lining as the final step in the operation.

On the whole, it would seem that excess of enthusiasm, or conservatism in some cases may have prompted the declaration for, and the rigid adherence to, the one material to the exclusion of the other.

It is recognized that specialization either with compound or with plaster enables different operators to produce dentures whose success

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cannot be questioned in either instance, even though one may use compound exclusively, and the other plaster alone, but for the student or the average operator, the combination of the two offers advantages which he cannot afford to overlook. The student especially should familiarize himself with the technic for both, so that in his future practice he may choose intelligently according to the conditions presented by the individual case.

Comparative Qualities of Plaster and Compound.—Plaster and compound exhibit their plasticity under totally different conditions and as a result of totally different methods of manipulation, and pass from the rigid to the plastic state under widely varying laws of matter. Plaster, a white, practically insoluble mineral powder, when mixed with water, exhibits a chemical change which results in the formation of crystals and ultimately a hard, dense solid, which thereafter cannot be restored to the plastic state without altering its form and destroying the integrity of the mass.

Compound, a dense, amorphous synthetic solid, a combination of mineral and vegetable substances, attains its plasticity merely by the application of heat, either wet or dry, and passes to the rigid state again by a reduction in temperature, without any appreciable chemical change. This process may be repeated a number of times within certain limits of temperature, without materially impairing its working qualities. In this respect it has a great advantage over plaster for some impressions.

Plaster is disagreeable to many patients in its consistency, taste, or lack of taste, and its gritty, earthy feeling. Its tendency to trickle into the throat while in the plastic state, or when set, to break off in small fragments which also work into the throat, is more apt to cause "gagging" than when compound is used. It may also cause pain to sensitive teeth from its low temperature, and some even object to its dead white color. Too little attention has been given to these disagreeable features of its use, most of which can be removed or avoided by a little ingenuity and forethought for the patient's comfort. By having a solution at hand containing coloring matter such as carmine, and some flavoring substance such as oil of cassia, and adding a few drops of this to the water for the plaster mix, an agreeable color and odor are imparted and the taste improved. By using warm water for the mix, the shock of cold on sensitive teeth is avoided, and the tendency to work back into the throat can be largely controlled by the position of the patient's head, and by inserting only the minimum amount needed for the impression with some allowance for necessary surplus.

The taste of compound is disagreeable to some patients, but it is more nearly universally agreeable than plaster. Neither plaster nor compound are injurious to the tissues, except that compound may be if it is inserted when too hot. This can only occur as the result of carelessness, as the compounds which are prepared for impression use attain their best plasticity at a temperature considerably below the point of tolerance of the oral tissues, and are injured by a heat which would be uncomforatble to the patient.

Plaster will copy fine details with less pressure than compound, which is of undoubted advantage where an impression in their normal state is desired of easily displaced tissues. When conditions are such that the slight pressure necessary with compound may be applied, it reproduces fine lines with all the faithfulness necessary or desirable in dental work.

It has been urged in favor of plaster and against the use of compound, that the former when set will fracture instead of being distorted by forcible removal where undercuts exist. Compound will also fracture in removing from undercuts when chilled, but with much more difficulty than plaster, because of its greater tenacity. Instead of being regarded as prohibiting its use this should be recognized as a valuable quality and the limitations it imposes met by a modified technic. It has also been said that the greater the difficulty involved in taking an impression, the greater is the desirability of using plaster. This statement should be qualified. When for any reason, it is necessary to reproduce the details of undercuts or constricted spaces between teeth where such spaces have been partly closed after the loss of teeth, then plaster is the proper material for the purpose because of the fact that it may readily be fractured and taken away in sections, though the same effect may be secured usually by taking a compound impression, one section at a time, by the so-called core method. In making partial dentures, especially those of metal construction, it is usually neither necessary nor desirable to reproduce the undercuts in the first impression if the base-plate is to be made separately as a foundation on which to complete the second impression and the mounting of the teeth. In this case, the use of compound for the base-plate impression, followed by plaster for the second impression including the base-plate and the remaining teeth, seems a logical procedure, as it is attended by greater comfort for the patient and less difficulty for the operator.

Both plaster and compound pass from the plastic to the rigid state promptly. The time required for "setting," as this phenomenon exhibited by plaster is termed, may readily be modified within certain limits by manipulation and by the addition of other substances to the mix .which retard or accelerate the setting, and acceleration is much more easily accomplished than retardation. A good grade of impression plaster is expected to set in from three to five minutes when mixed in the ordinary manner. Protracted stirring during the mix, the increase of the amount of plaster in proportion to the water, and the use of warm or hot water all increase the speed of setting. These measures may be employed either singly or in combination.

Acceleration of setting is also accomplished by the addition of substances known in chemistry as catalyzers, which modify the chemical reaction, but apparently do not enter into the resultant new chemical compound formed in the reaction. Potassium sulphate and sodium chloride, sprinkled in small quantities in the water before making the mix, are commonly used for this purpose, but many other substances have the same effect. Ordinary sugar is said to act very satisfactorily as a catalyzer and to improve the taste of the plaster. Retardation is seldom resorted to, but can be accomplished to some extent by reducing the amount of plaster in proportion to water in the mix, and by the minimum amount of stirring which will serve to combine the two. Thinning the mix cannot be carried very far without making the plaster, when set, so weak and friable as to greatly impair its usefulness. Further retardation may be had by the use of a catalyzer, which in this case may be said to have a negative action. Glue dissolved in the water is said to have this action and not to impair the strength of the plaster when set. For impression work it is almost invariably desired to reduce rather than increase the time of setting, because the plaster can be very quickly introduced into the mouth and carried to place without delay, after which, the more rapidly it sets, the better. Rapid setting reduces the liability of the plaster washing away from the edges of the impression in the saliva, and also makes for the comfort of the patient. It is well to bear in mind also that accelerated plaster evolves more heat than when allowed to set slowly, therefore if hastened too greatly in its setting it is likely to cause discomfort when used in the mouth.

Compound cannot well be controlled in its time of hardening except by the amount of heat applied to soften it, or more properly, the temperature at which it is introduced into the mouth, and by the use of cold water to chill it when in position. The latitude of temperature variation with maximum plasticity is small, but the use of cold water to hasten hardening is quite permissible after the initial hardening has begun, though this is usually not necessary.

Both plaster and compound are subject to further physical change after the initial set or hardening has taken place. Plaster expands during the process of setting and continues to expand more slowly for a considerable and variable length of time afterward. No experimental work bearing on volumetric changes in compound has come to the writer's notice. It is generally believed to be subject to very little if any expansion or contraction after once becoming thoroughly cooled and hardened, but a compound impression is thought to warp or become distorted from the original shape to some extent when again exposed to moderate variations in temperature such as would occur in an ordinary room. In the absence of experimental proof it seems reasonable to assume that this would be the case. Being made plastic by heat and molded into form while in that condition, then hardened by removal of the heat, some parts of the mass must be under greater tension than others, tending to make it revert to the original form. Impressions consisting of a thin layer of compound, or alternating thick and thin sections, are therefore more likely to become distorted than those of a uniform thick mass.

For the above reasons it is best to prepare and fill all plaster and compound impressions with the cast material as soon as possible after their removal from the mouth, for while the error due to such changes may not be very great, it is added to the total of the errors inevitably accruing in the process of producing a denture from the intial step comprised in the impression.

Compound does not deteriorate in any perceptible manner when kept on hand indefinitely. The same cannot be said of plaster, which slowly absorbs moisture from the atmosphere, becoming "air slacked," as it is termed, and thereby having its setting qualities materially altered, unless it is stored in air-tight receptacles, completely filled and sealed.

Derivation of Plaster.—Gypsum, from which plaster is made, is a mineral substance widely distributed in the earth's crust. Chemically, it is a hydrated calcium sulphate, having a formula of $CaSO_4+2H_2O$, from which a portion of the water is driven off by heat to form plaster, leaving a half-hydrated calcium sulphate with the formula: $CaSO_4 + \frac{1}{2}H_2O$. Gypsum occurs in large opaque, crystal masses of various colors, the latter due usually to the oxides of iron which it contains as an impurity, and which impart to it varying shades of yellow, brown and red, and even color it black. A fibrous form of the mineral is known as *satin spar* or *fibrous gypsum*; the snowy white, translucent variety known as *alabaster*, and a crystalline, transparent variety known as *selenite*.

Gypsum used in the manufacture of plaster is seldom found in a pure state, but contains various other substances in small quantities as impurities, such as magnesium or calcium carbonate, iron oxides, clay and sand or silica, which do not materially impair its properties for building purposes, but are objectionable when it is to be used for dental plaster. Selected rock only should be used for this purpose, and the manufacturing processes must be carried out with close attention to all details if uniformity of working qualities is to be assured.

Process of Manufacture.—Briefly described, the preparation of plaster consists of a partial dehydration of the dihydrate gypsum by means of calcination, thus converting it to the half-hydrate, pulverizing or grinding, and the separation of the ground product into different grades of fineness by sifting or equivalent means. For some purposes the elimination of water is carried still further, and such products are commonly referred to in a general way as "overburned" or "dead burned" plaster.

Pulverization may precede the calcination, as in the early method known as the "kettle" process, or the procedure may be reversed, as in the more modern rotary cylinder process. The latter is a continuous process by which the rock, first broken into pieces of convenient size, is introduced into a rotary kiln of tubular form, through which it slowly progresses for a length of time governed by the speed of rotation and in accordance with the temperature used, which is varied to suit the use for which the resultant product is intended. From the kiln, it is led to the grinding or pulverizing machinery, which in some plants consists of a "ball mill" that reduces the lumps to powder by the impact of balls in the interior of a rotating, barrel-like drum. By some manufacturers, the finer particles are drawn off by a current of air (hence "air-floated") and collected in suitable chambers as dental plasters, the coarser grades being used for building purposes, and modified usually by the addition of accelerators or retarders for special uses. In some cases dental plaster is also modified, usually by an accelerator, according to the practice of the individual manufacturer and the characteristics of the rock peculiar to the locality from which it is obtained.

When properly mixed with water, plaster has the property of taking up the molecule of water of which it has been deprived, and of again becoming a dihydrate by the process of crystallization. The speed with which the crystals form is governed by several factors: the fineness of the particles, the degree of dehydration, the temperature of the water, and the presence of accelerators or retarders incorporated by either the manufacturer or the user. The strength of the crystallized mass is directly proportional to the size of the crystals and the slowness with which they form, the latter determining their compactness by intimate contact and interlacing. Impression plaster therefore, which is required to set speedily, is a relatively weak plaster and not fit for other uses.

The claim is made by some manufacturers of dental plaster that their product is made from the highest grade and purest quality of gypsum obtainable, without the addition of accelerators or retarders, but the temperature at which they calcine and other details of the process they are inclined to regard as "trade secrets." It is known, however, that calcination at temperatures above approximately 190° C. leaves the product with less than one-half molecule of water, approaching the anhydrous state as the temperature is increased above that point. Such plasters set very slowly, requiring many hours or days, but attain greater hardness, and in general their expansion may be said to be less. By adding an accelerator in the process of manufacture, as previously mentioned, the setting time is kept within usable limits, without materially impairing the hardness. In general such plasters are known commercially as "cement" plasters, or "hard finish" plasters. In recognition of the value of the hardness and low expansion of such a product in dentistry, several plasters of this type have come into more or less general use in recent years in prosthetic work under the rather misleading general name of "artificial stone." The purposes for which they are adapted and other details will be taken up later.

Compound is prepared by comparatively few manufacturers, who generally consider their formulæ and methods of combination trade secrets, so that it is not possible to give herein any definite information in this regard as to the various brands. The basis of the material is known to be a combination of one or more vegetable gums or resins with mineral fillers, flavoring and coloring matter. The resins suitable for this purpose are the same as those used in varnish making, such as copal, dammar, and kauri. Powdered talc, commonly known as soapstone, is used as a filler and possibly some of the infusorial earths. Stearin helps to control the stickiness of the gums, while carmine or some dye material may be used to impart the color.

Prothero quotes a formula furnished by E. Loyd Williams of London, with instructions for compounding, which may be considered typical of this class of materials. It is as follows:

Kauri	1 part
French chalk	1¾ "
Stearin	1½ "

"The stearin is first melted, the kauri added, and the two thoroughly incorporated, then the chalk is gradually sifted in and the mass kneaded until well mixed. The coloring and flavoring ingredients should be incorporated in the stearin and gum before adding the soapstone." This formula is said to produce a yellowish-white material.

A German investigator,[1] in reporting an examination of materials of this class writes in part, as follows:

"The plastic impression materials used in dentistry are composed chiefly of resin and stearin, to which, for the sake of obtaining a certain consistence, fillers, such as talcum, are added. Some dyestuffs and a few drops of an ethereal oil improve appearance and taste. Under a low-power microscope these materials present the picture of a uniform surface, permeated by fatty acid needles, particles of the filler employed and the coloring matter. Besides these we observe more or less dissolved resin particles which are easily recognized by their yellow color. The size of these resin particles directly influences the plasticity of the material . . . The temperatures at which the various materials tested became soft and workable varied between 41° and 45° C. . . . The tests carried out by the writer with the micrometer method of measurement showed in the various brands examined, a variation of contraction of from 0.005 to 0.035 mm. . . On the whole the volumetric changes in these impression materials do not differ very widely, since a difference in temperature of only about 20° C. is to be reckoned with, the various materials being workable at from about 40° to 60° C. . . ."

"If placed in boiling water the composition of modeling compound is altered entirely. Fatty acids and resin particles are dissolved or melted out, and the change in the quantitative ratio of the materials contained in the compound naturally alters the physical behavior of the mass."

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[1] Schvenbeck, F.: Zahnarztliche Rundschau, January, 1913.

Brands, Packages Supplied.—Dental plasters are offered for sale under many brands, some for special purposes, and with various claims of superiority. There are undoubtedly slight differences due to the manufacturer's individual practice as to calcining, grinding, accelerators added, blending, and the source from which the rock is obtained. It has been the writer's experience with various brands, which probably holds true for all, that each will give good results if its peculiarities are determined by experimental mixes, the manufacturer's directions followed and reasonable care used to prevent deterioration by exposure to the air. The last is particularly necessary with impression plaster, since its most essential quality, rapidity of set, is quickly impaired by absorbing moisture from a humid atmosphere. For this reason, it is best to obtain it in small packages, or at least to keep a small quantity for immediate use separate from the main supply. Plaster is sold in packages containing from approximately 1 quart up to a barrel, so that the needs of any user may be met conveniently.

The use of compound for impressions has become restricted almost entirely to one brand, because of its superior qualities of fineness of grain, low heat required for its softening, and prompt hardening as soon as its temperature is again somewhat reduced. No deterioration problem being involved, the packages are of practically uniform size, and for convenience, several forms of the material are supplied, namely: cakes for impressions, wafers for refitting plates, and sticks of two degrees of softness for adding small quantities of the material in melted form around edges or other parts of the impression.

Reference has already been made to a compound supplied for the special purpose of forming the tray for plaster impressions.

EQUIPMENT FOR IMPRESSION TAKING.

The equipment necessary for using either plaster or compound is quite simple, especially for plaster. More elaborate apparatus which has been developed for compound adds to convenience in its use but is not essential for entirely satisfactory results.

For plaster impressions, a bowl for mixing, and a spatula for stirring, some coloring and flavoring material and accelerators previously mentioned, are practically all that is necessary.

Impression trays for carrying the mix to the mouth and holding it while setting will be described later. The bowl may be of porcelain, with a rounded bottom which presents advantages in appearance and cleanliness, or the rubber bowl made especially for mixing plaster, which has come into quite general use. The latter is obtainable in several sizes, and has advantages in its flexibility which makes it easy to bend up the edge and use it as a spout in pouring, the ease with which it may be cleansed even after the plaster has set, and its unbreakableness. Steel spatulas, of the type used by druggists, are frequently used by dentists for mixing and placing plaster, but are ill suited to this purpose because of their great flexibility and the difficulty of keeping the blade free from rust. Spatulas made of nickel alloy are obtainable, and are far better for dental use than those of steel.

For compound impressions, the material may be softened either by dry heat or in hot water, but the wet method is to be preferred. For this purpose, an enameled pan, preferably with straight sides, in which to heat the water and soften the compound, means for producing heat such as a Bunsen burner, and a spider on which to support the pan are required. While good results may be obtained even with this meager equipment, it will be found difficult to constantly maintain the temperature best suited to the compound, and to avoid overheating it or having it stick to the pan. By applying the heat by means of a small electric heater of the immersion type suspended below the surface of the water, but not at the bottom, and by adding a thermometer fixed in the pan, a much better control of the heat can be secured. Sticking of the material will not so readily take place, and can be prevented by a piece of thick rubber dam laid on the bottom of the saucepan. An apparatus designed along these lines and giving most satisfactory results in use is on the market (Fig. 57).

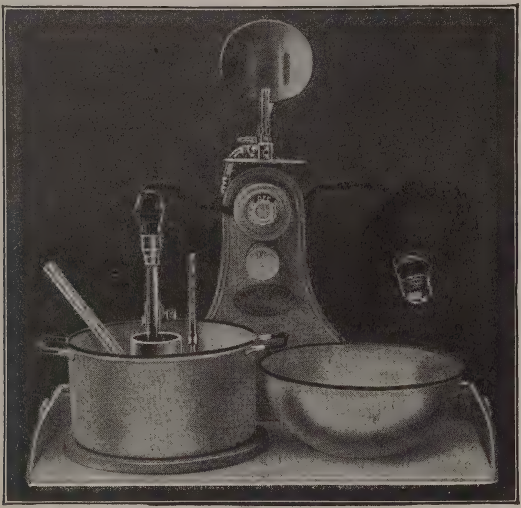

FIG. 57.—Supplee's heating outfit for compound. (Wilson.)

In addition some means should be provided for softening thin edges or small areas of the compound while modifying the impression. A small and convenient mouth blowpipe has been devised for this purpose which can be attached to the ordinary alcohol lamp or Bunsen burner, and produces a tiny flame easily controlled and directed. The bench blowpipe designed for fine soldering such as orthodontia work will also serve the purpose successfully.

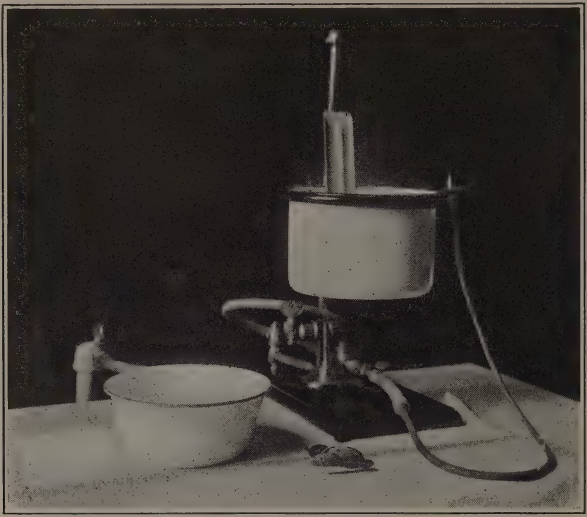

Fig. 58.—A student's compound heating outfit with waxing torch attached. Front view.

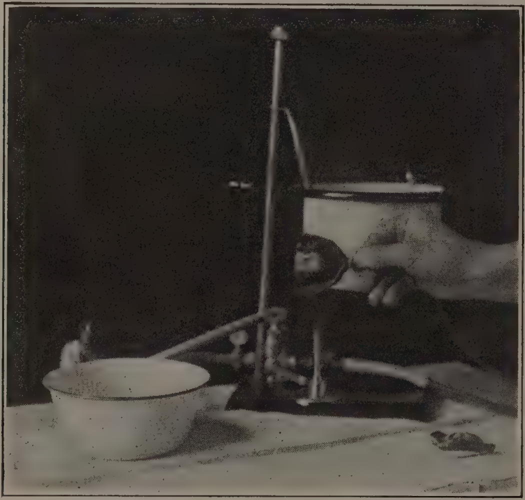

Fig. 59.—Student's compound heating outfit, side view. The Bunsen burner is in use for softening the impression along the periphery.

A device for heating compound was designed by the writer primarily for students, and has proven to be highly convenient and practical for office use also. It utilizes gas alone for heating, requiring only a piece of rubber tubing for attachment to any gas cock, and no wire connection. It is so simple in construction and operation as to be almost proof against getting out of order in any way, and eliminates the expense and delay incident to the occasional "burnout" of an electrical heating unit. It is made of standard gas fittings, together with a thermometer, two small dental office gas burners (one known as a waxing torch) and is mounted on a ring stand of the kind used in chemical laboratories, which holds the bowl for hot water. Another bowl for cold water is placed close at hand on the table (Figs. 58, 59 and 60).

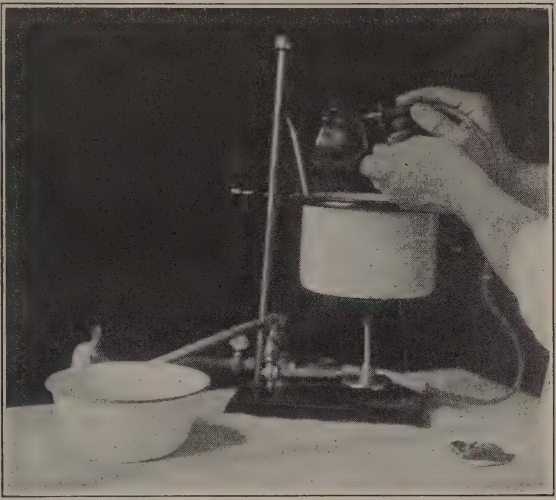

FIG. 60.—Student's compound heating outfit. The waxing torch is in use for softening a small area of the edge of the impression. The Bunsen burner has been swung under the hot water bowl to keep the contents at the proper temperature.

Impression Trays.—To carry the impression material to the mouth and retain it while hardening, an impression tray of some sort is required.

This is usually in the form of a shallow cup, conforming somewhat to the shape of the upper or lower arch for which it is intended (see Figs. 61 to 65). Sometimes the tray may be dispensed with entirely, as in the case of some small compound impressions, when the material is introduced as a lump and pressed into place with the fingers or in a small plaster impression, when the material may be carried to the area desired with a spatula and allowed to settle into place while still plastic, or pressed in contact with the tissues by the patient's lips, cheeks, or tongue.

Impression trays are furnished in a great variety of shapes graduated for all sizes of dental arches, not only for the entire arch, but for small areas as well. The partial trays are available for a right or left half

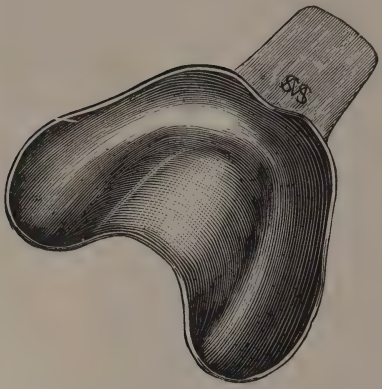

Fig. 61.—Edentulous upper impression tray for plaster.

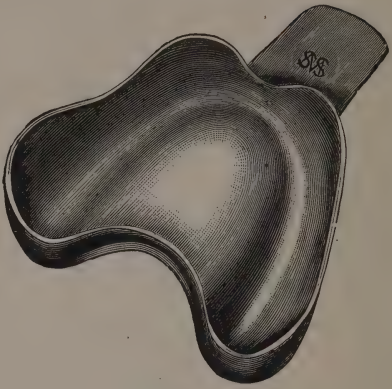

Fig. 62.—Edentulous upper impression tray with deep flange for plaster.

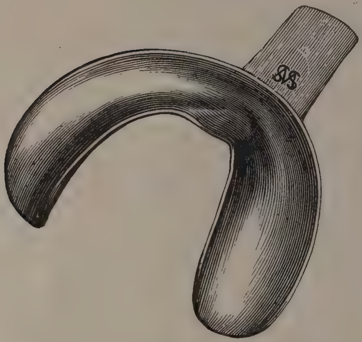

Fig. 63.—Edentulous lower impression tray for plaster.

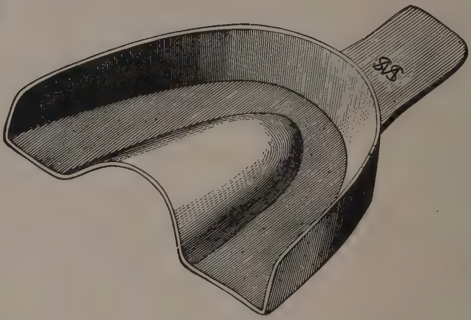

Fig. 64.—Tray for partial upper plaster impressions.

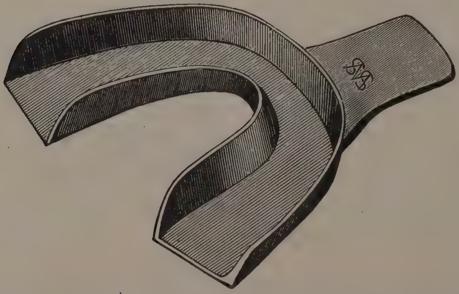

Fig. 65.—Tray for partial lower plaster impressions.

of either upper or lower jaw, for the anterior portion only, or for some special types of work and are made so that they may be used in any part of the mouth. One of this variety is made with a handle which can be swung in any direction, and is known as a crown and bridge tray (see Fig. 66). Small trays with hinged backs are also furnished for taking impressions of a single tooth or several adjoining teeth.

Trays for taking impressions of edentulous mouths are made with rounded bottoms to conform somewhat to the shape of the gums after resorption has taken place, those for the lower jaw also being curved in the antero-posterior direction. Those intended for taking impressions of a full arch of teeth or teeth remaining at intervals are made with flat bottoms and high sides, and still others are furnished with depressed or cut out portions to receive the imprint of a group of teeth in the anterior part of the mouth, and a curved portion at a different level for the impression of the posterior portion of the ridge where the teeth are missing (Fig. 67).

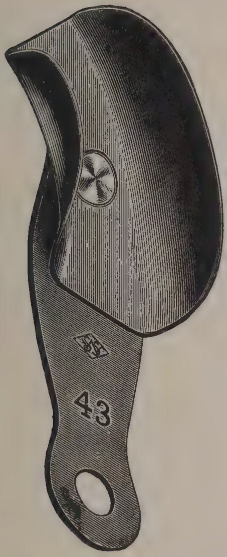

Fig. 66.—Tray for partial lower impressions with anterior teeth. (Wilson.)

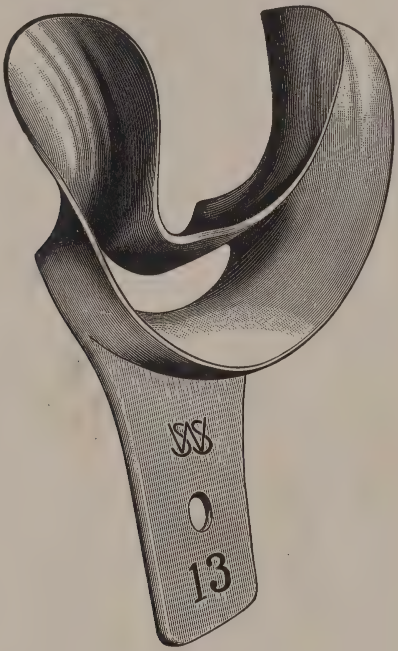

Fig. 67.—Crown and bridge impression tray, universal. (Wilson.)

A greater variety of trays is furnished for plaster impressions than for compound impressions, and those for compound are of simpler form, for the reason that the tray is of greater importance in the success of a plaster impression than of a compound impression. Some operators dispense with the tray entirely in taking a compound impression of an edentulous mouth, using a broad flat spatula-like piece of metal to carry the mass of compound to the mouth for the first insertion, after which even this is discarded. Some operators, in taking a plaster impression, first use a tray to carry compound in which to get an imprint of the jaw, after which the metal tray is discarded and the compound used as a tray for the plaster to complete the impression. For partial cases presenting special difficulty because of undercuts, irregular alignment of the teeth or unusual shape of the alveolar ridge, it is often advocated that special trays be made, but this is seldom necessary if a combination of plaster and compound be used, or if a metal or vulcanite base-plate be made prior to the mounting of the teeth. Some advocate the swaging of metal trays on dies for each edentulous case, claiming thereby to obtain more certain and definite results, but in view of the excellent results attained without this extra step, it may well be omitted by the skilled operator in all cases but those of abnormal shape and size, and special cases where large portions of the alveolar process have been lost.

The impression tray serves other purposes than that of carrying the impression material to the mouth and holding it in position. The handle of the tray affords a convenient means of guiding the impression to place, and indicates the relative position of the tray with reference to the cheeks and lips. When a plaster impression must be removed in several irregular sections separate from the tray, the latter may be used as a guide in which to assemble the different parts in their correct relation.

Materials Used for Impression Trays.—Impression trays are usually made of metal for durability, strength and lightness and a certain amount of rigidity. Various other materials have been tried, such as porcelain, or other earthenware, celluloid, and heavy waxed paper, but most of these, either because of too rigid construction, or some other lack of adaptability, have found a very limited use or have been entirely discarded. The trays commonly used are of Britannia metal or similar alloy, or of sheet aluminum, both of which permit ready trimming and bending to adapt the tray to the individual case and yet possess sufficient rigidity to maintain the shape even with considerable pressure. The Britannia trays are made by casting the low-fusing alloy into molds, while the aluminum trays are pressed in dies. Cast aluminum trays, as usually manufactured, though light and strong, are too rigid to be readily adapted by bending and therefore have not proven very successful. The small trays used for crown and bridgework and for impressions of single teeth are furnished in brass, nickle plated. When it becomes necessary to make a tray by swaging for a special case, block tin, heavy sheet lead, sheet brass or aluminum may be conveniently and successfully used. It is frequently found convenient as well as a saving of time, to bend sheet wax into an approximate form and use it for taking a plaster impression of a small area, including one or more teeth.

IMPRESSION TECHNIC.[1]

Position of the Patient.—For all impressions, the seating and position of the patient should receive careful attention, and are of great importance to both the patient and the operator, in order to assure the maximum of comfort to the patient, and permit of the greatest convenience and accessibility for the operator. For plaster impressions particularly, the patient's clothing must be carefully protected from small fragments which become detached, and from the possible overflow of saliva stimulated by the presence of the plaster in the mouth. A large towel fastened at one end around the patient's neck, and so placed as to cover the lap as well as the chest, is usually sufficient. A specially made bib, large enough to cover the shoulders and arms as well as the chest and lap, affords positive protection, and makes a good impression on the patient by the evidence of care it affords.

It is assumed that a dental operating chair is to be used, though a very satisfactory chair for impression work is obtained by fitting a library armchair having leather cushions, with a portable head-rest, and mounting on a low platform to give it sufficient height. No matter what chair is used, in taking impressions the patient's head should never be tipped back, and the chair itself should be inclined but slightly from the vertical.

An approximate rule to follow as to the relative position of the patient and operator for upper impressions, is to have the patient's chin on a level with the operator's elbow, and for the operator to stand at the side of, and slightly back of the patient, partly turned toward the patient, but facing in the same general direction (Figs. 68 and 69). For lower impressions, the patient's chin should be about on a level with the operator's shoulder, who stands at the side, slightly in front of, and facing the patient (Figs. 70 and 71).

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[1] For convenience and brevity the technic given here follows the mandatory form. It is to be understood that the procedures are typical, and are subject to variation as occasion demands. They form a composite, drawn from experience, observation and the writings of others, to whom the writer gratefully acknowledges his indebtedness. In each case the method outlined has been found to give good results in the hands of students, who without doubt find impression taking one of the most difficult phases of prosthesis.

Too much credit cannot be given to the men who, by their earnest efforts and enthusiasm, have added to the knowledge on the subject, and increased the appreciation of its importance in determining the success of artificial dentures.

Among these may be mentioned the late Drs. J. W. Greene and George H. Wilson, Drs. Prothero, Giffen, Hall, House, Clapp and Tench, Mr. Supplee and others. For information regarding their special methods, the merits of which cannot be discussed here, the reader is referred to current dental literature.

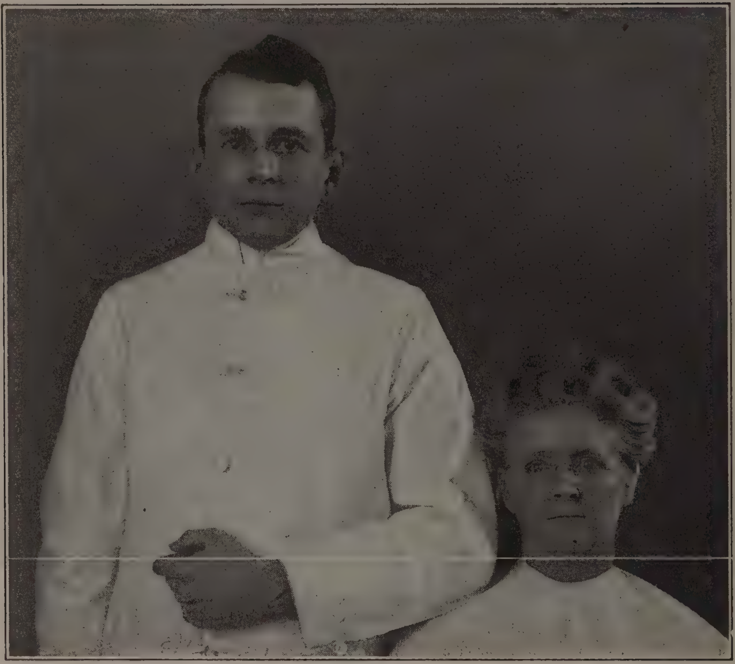

Fig. 68.—Proper relative positions in height of patient and operator for taking upper impressions.

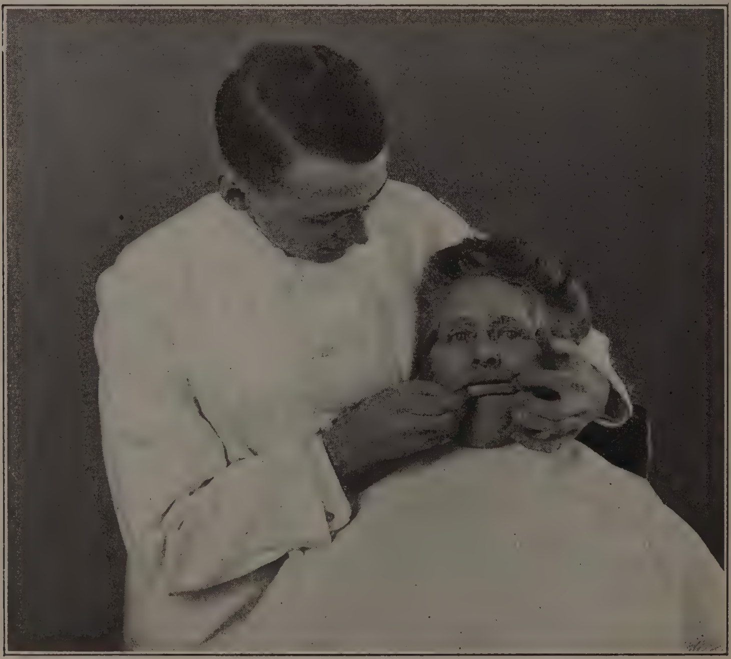

Fig. 69.—Inserting the tray in taking an upper impression.

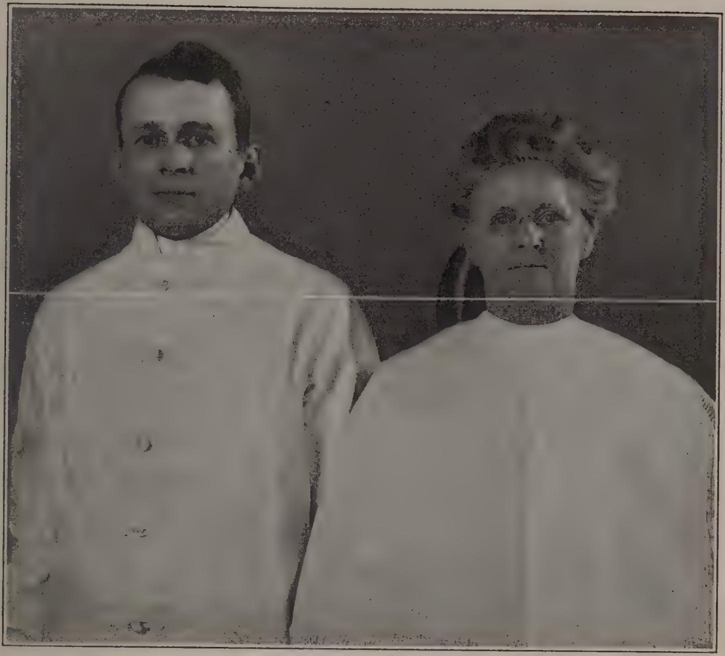

FIG. 70.—Proper relative positions in height of patient and operator in taking lower impressions.

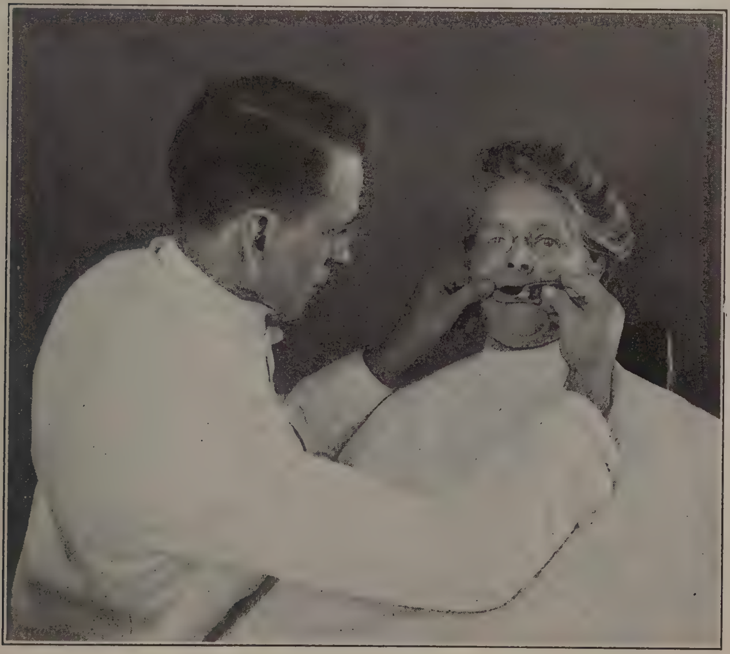

FIG. 71.—Inserting the tray in taking lower impressions.

PLASTER IMPRESSIONS.

Selecting the Tray.—*Edentulous Cases.*—Observe the form of the arch, its symmetry, outline and height, and in the upper jaw, the height of the vault. By comparison, select a round-bottomed tray which approximates the size of the arch, with preference for one which may be somewhat too large rather than one that may prove to be too small. Try it in the mouth, settle it gently to place, and with a mouth mirror examine the position of its periphery with reference to the soft tissues and make sure that its posterior border, in the upper jaw, passes well over the tuberosities and reaches to the junction of the hard and soft palate, previously determined by digital examination, and marked, for convenience, with an indelible pencil. In the lower jaw, see that it reaches the base of the ramus where it begins to curve upward. See that the walls of the tray reach to the base of the ridge, with a slight space existing between the bottom of the tray and the summit of the ridge, as nearly as may be determined.

Trimming and Adapting the Tray.—Wherever the tray may impinge on soft tissues at its periphery enough to cause discomfort, trim it away with shears, and smooth with a file. If it does not entirely include the areas desired, select a larger one, or build it out with compound until it does. Bend the walls of the tray inward or outward as may be necessary, so that they will not touch the sides of the ridge; an allowance of about 3 mm. between tray and ridge is to be made for the plaster.

Make similar adaptation, if possible, for the vault in the upper jaw, flattening or deepening the curve of the bottom of the tray as may be indicated. If the vault be a very high one, it will be necessary to build up the bottom of the tray in the posterior part, as follows: have the surface of the tray dry, and lay on it a small roll of compound softened by dry heat. Work this into approximate shape with the fingers, dip in hot water, insert in the mouth, and press the tray gently to place to form the compound to the surface of the palate. Remove, and trim any surplus or sharp edges. This roll or ridge will insure the plaster being carried into contact with the tissues when taking the impression, and also will cut it off with a clean definite edge.

To extend the edge of the tray at a deficient place, have it dry, smear the surface with the end of a stick of compound heated in the flame to the sizzling condition, add a small mass of compound softened by dry heat, pinch it into the approximate shape desired with wet fingers, then carry the tray to the mouth and adapt the addition to the tissues by gentle pressure. The object sought in thus adapting the tray is to have it carry the plaster positively to all the area to be included in the impression and slightly beyond, without causing undue pressure at any point. Never score or mark a tray to make the plaster stick to it; it is better to smear its surface with a stick of sizzling hot compound, or melt wax on it.

Selecting Trays for Partial Cases.—Use the flat-bottom type of tray for partial denture cases, or when an impression is desired with all the teeth present, as for instance in orthodontic work, for which a special type of tray with very high sides has been designed.

Fit and adapt the tray in a similar manner to that described for edentulous cases, but make allowance for a larger bulk of plaster around the teeth buccally and along their occlusal surfaces, as these parts of the impression must usually be fractured and removed separately from the main section, and will become comminuted and difficult to reassemble if the plaster is in too thin a layer.

For a lower or an upper case with only the anterior teeth present, trim away all the labial wall of the tray corresponding to the area that these teeth occupy. For cases with teeth and spaces alternating around the arch (Fig. 72), leave all the tray walls intact, or adopt an alternative method as directed under "Compound Sectional Impressions."

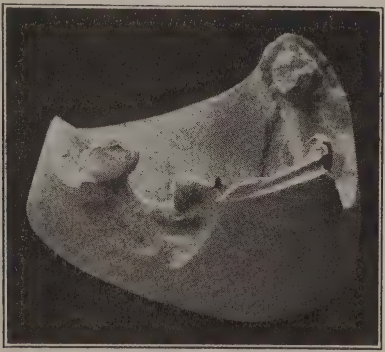

Fig. 72.—Partial lower with teeth and spaces alternating. For plaster impressions of this type of case the tray should be fitted with labial and buccal walls intact, as in Fig. 65.

Making the Mix.—Measure in the bowl 30 to 50 cc. of tepid water, which is sufficient for any impression of ordinary size. Add a few drops of coloring solution and a small pinch of the accelerator in powdered form, if it is desired to use one. Slowly sift in impression plaster with an ordinary small size wire kitchen strainer of about a half-teacup capacity by tapping on the handle. When plaster has been incorporated until all the water appears to be absorbed, cut the spatula through the mass rapidly several times and stir only enough to insure complete combination of the water and plaster. This will produce an average consistency, which may be easily tested for a lower impression by placing the plaster in the tray with the spatula or by pouring from the lip of the bowl. Invert the tray; if the plaster drops too readily, return it to the bowl and sift in a slight additional amount. Make the mix deliberately, but get it into the tray and carry it to the mouth as promptly as possible in order to leave the maximum time for manipulation of the plaster in the mouth before setting begins.

Endeavor to proportion the amount of plaster to the size of the impression and the area it is to cover, with only a slight surplus.

Inserting the Tray.—Caution the patient to open the mouth only partly, so as to leave the labial muscles relaxed.

Upper Impression.—For an upper impression with patient and operator in the positions previously described, first insert the side of the tray nearest the operator into the corresponding angle of the mouth, with slight pressure to distend the mouth orifice, and at the same time, with a finger of the free hand, hold the opposite corner of the mouth out of the way so that the tray can be rotated past it (Fig. 69). Center the impression by means of the tray handle by observing its position relative to the median line, and settle it to place with gentle pressure and a rocking motion.

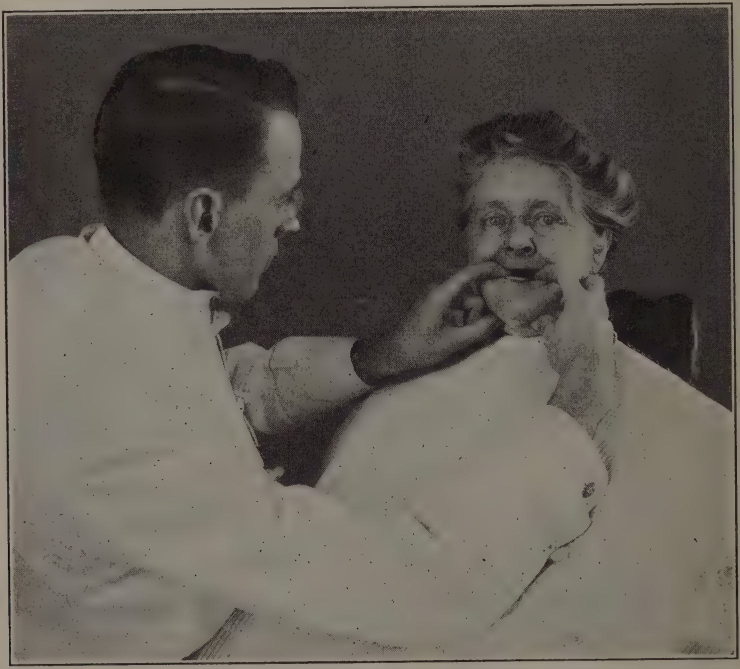

Fig. 73.—Holding lower impression in place during setting of the plaster.

With a finger of the free hand, draw the lip out from the tray all around and allow it to settle back evenly, making pressure, if necessary, through the lip and cheek to direct the plaster into the space at the base of the ridge. Next stand directly back of the patient and with a finger of each hand under the tray in the bicuspid regions, have the patient incline the head slightly forward, and hold the impression steadily, with light pressure, until the plaster sets. This position of the patient reduces the tendency to nausea often encountered, by permitting the saliva and small particles of plaster to run forward and to be readily removed in a towel by the patient or the assistant.

Lower Impression.—After having arranged the relative position of patient and operator as described for a lower impression, proceed as for an upper case with these exceptions: Insert the side of the tray *farthest* from the operator first at the corresponding angle of the mouth (see Fig. 71), and when holding the impression during setting, retain the operator's original position and place a finger of each hand on top of the tray, with the thumbs under the lower jaw (Fig. 73).

Test the plaster remaining in the bowl as setting takes place, by pinching between the thumb and finger small fragments broken from the mass. When they crumble with difficulty, without the appearance of free water, it is safe to remove the impression, with the assurance that any fractures that may occur in doing so will be produced with sharply defined edges without crushing. This stage of setting may be somewhat anticipated for edentulous impressions, and in any case setting of the impression will be somewhat in advance of the plaster left in the bowl because of the heat of the mouth.

Removing the Impression.—For edentulous impressions, it is usually only necessary to make slight pressure on the handle of the tray with an up and down rocking motion. The patient may assist to some extent by puffing out the cheeks and working the facial muscles. Occasionally it may be necessary to lift the lip and direct a stream of water from a syringe around the edges of the impression. Marked adhesion in such cases is often deceptive as to the success of the impression, being due partly to the absorption of all the free moisture on the surface of the tissues, and a test by reinsertion will show less "suction."

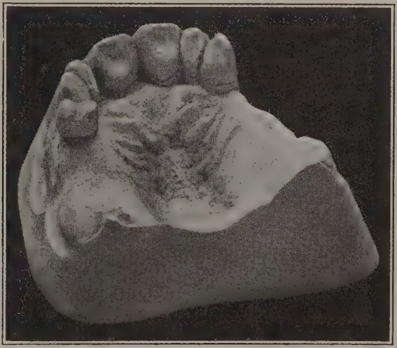

Fig. 74.—Partial upper with teeth in unbroken row and parallel axes.

For partial cases including a small group of teeth in a row (Fig. 74), somewhat more force must be used, with the idea of fracturing the plaster over the teeth at the ends of the row especially. Where several teeth alternate with undercut spaces, and for orthodontic impressions, use the same method, allowing the plaster to fracture where it will. A better method is to detach the tray entirely by a sharp rap on the handle. Provide for this in advance by having the interior of the tray clean and smooth and by varnishing any portion which has been built on with compound or wax; after removing the tray make cuts along the entire length of the occlusal surface over the teeth and vertical ones in the cuspid regions, which will thus determine the lines of fracture. Remove the labial section first, by pressure applied at its edge incisally and outward, then proceed similarly with the two buccal sections and finally remove the palatal or lingual sections. Much difficulty is often experienced because separate fragments remain in undercut spaces between converging teeth (Figs. 75 and 76), and become so comminuted in removal as to make an accurate reassembly impossible. In such cases, resort to the core method or sectional impression method with compound.

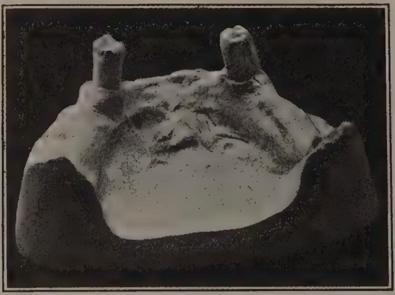

Fig. 75.—Partial lower with isolated teeth not parallel. Sectional impression indicated.

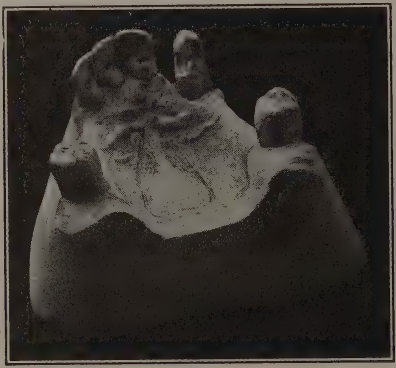

Fig. 76.—Partial upper with undercut spaces and teeth alternating. Sectional impression indicated.

Core Method.—Press small masses of softened compound into the undercut spaces (Figs. 75 and 76), chill, and trim while in place sufficiently to remove laterally without distortion. Trim the occlusal portion to a flat smooth surface somewhat shorter than the adjoining teeth, and likewise cut the buccal and lingual surfaces so that they taper slightly to the occlusal. Make these three surfaces smooth and rub them sparingly with vaseline. Insert these cores in proper places, then proceed with the plaster impression as above, fracture, remove, and assemble the different pieces including the cores, whose relative positions are clearly defined by their smooth surfaces and sharp angles.

Sectional Impressions with Compound.—Select a flat-bottom tray and cut away the labial and buccal walls. Smear the interior surface with sizzling hot compound. Soften a mass of compound, mount on the tray in some semblance to the shape of the area to be covered by the impression, molding with moist fingers. For an upper case, pinch the mass into an elevation in the center of the tray so that this part will touch the hard palate first when inserted. Dip in hot water, or pass the surface of the compound through the flame of the burner to soften it. Insert as directed for plaster impressions, and settle to place only partly until the compound is seen to enter the undercut spaces. Allow time for the compound to become partly hardened, but not rigid, then remove by moderate force with a rocking motion. Trim away all parts which have entered the undercut spaces far enough to drag when removed, and all the posterior part where it is not intended for the plate to cover the tissues. Again soften the compound by dipping the surface in hot water and passing through the flame, or by using the mouth blowpipe, but endeavor to keep the interior of the mass somewhat rigid so that it will act as a core to force the softened part into correct adaptation. Reinsert and press to place with sufficient pressure to cause the softened surface layer to *flow* to all parts desired in the impression including the occlusal surfaces of the teeth, but not to the buccal and labial surfaces of the teeth nor to those parts of the undercut spaces which open as embrasures to the buccal or labial side. Allow the compound to harden, and after removing it, trim away any edges encroaching upon the area last named. If any parts are now deficient around the periphery or the lingual surfaces of the teeth, "trace on" additions of compound at those points, and reinsert for adaptation. At this stage, for lower impressions of this type, it is well to trim the periphery, especially the lingual part, or modify it by additions, until the impression covers only the parts to be included by the plate, without impingement on muscular tissues.

The impression is now completed in all but the labial and buccal portions. To complete these, hold the main impression in place and mold upon the labial and buccal aspects of the teeth and gums one or more strips of compound, overlapping upon the edges of the tray. Let these portions harden thoroughly, or chill with a stream of water from the syringe. Remove all the parts and assemble with sticky wax at the junction of the sections and where the sections overlap upon the tray. Slight ridges upon the cast indicating the lines of junction may usually be trimmed without impairing the accuracy to any extent.

An alternative method of completing the buccal and labial parts of the impression is as follows: Shape one or more strips of wax or compound along the edges of the tray to replace the walls that have been cut away and lay these strips aside. Put the modeling compound section of the impression in place in the mouth, heap impression plaster mixed to a heavy creamy consistency upon each strip and use it as a small tray to carry the plaster to position upon the labial and buccal surfaces of the teeth and hold it there until set, when the various parts may be removed and assembled as above.

For all of these partial cases with undercut spaces alternating with teeth, some operators prefer to take an impression as described above, without the buccal and labial sections, and including the lingual surfaces of the teeth, but not the occlusal, allowing the impression to only partly fill the undercut spaces labially or buccally so that it may be withdrawn without dragging or distortion. From this make a cast and vulcanite base-plate. The base-plate is fitted in the mouth, and any peripheral corrections or additions that are necessary are made by tracing on compound at the points indicated and by reinsertions in the mouth. With this corrected base-plate in the mouth, a plaster impression is taken including the base-plate, the remaining teeth, and clasps, if these are being fitted, and removed by fracturing. Then the fragments are assembled together with the base-plate, forming a composite impression, from which another cast is made. Such a cast is fairly accurate in establishing the positions of the clasps and the remaining teeth relative to the base-plate. The base-plate is further utilized by mounting upon it the artificial teeth for trial in the mouth, after which it is either discarded in the second vulcanization or new rubber added to it to retain the teeth. This method has much to recommend it. Besides simplifying the impression taking, it presents many of the advantages of a rigid, accurate base-plate when taking the bite and trying in the teeth that are attained in the use of gold or other metal bases for artificial dentures.

Modeling Compound Edentulous Impressions with Plaster Finish.—First take a preliminary or test impression with a loose-fitting round-bottomed tray and enough compound to overextend the impression somewhat in all directions, but with little attempt at accuracy or detail. Run up a thick cast with quick-setting plaster. Separate, and on the cast adapt a tray suited to the individual needs of the case.

(It is to be understood that trays of thin soft aluminum are used, Fig. 77, which are readily adapted with the fingers and by burnishing with a heavy blunt instrument. The rounded end of the plaster spatula handle or a file handle serves this purpose. After experience is gained, trays may be fitted in the mouth for the upper denture, without the plaster cast, but students should not omit this step, especially for lower dentures.)

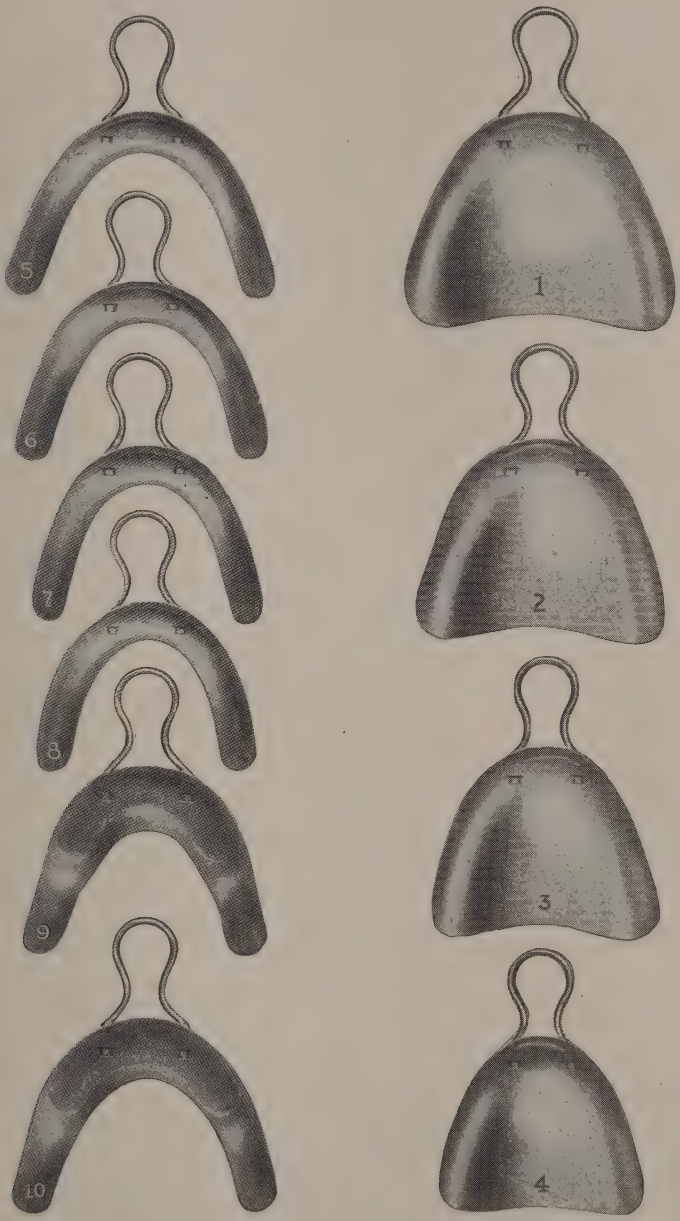

Fig. 77.—Greene-Kerr impression trays.

Having fitted the tray on the rough cast, try it in the mouth to see that there is no muscular interference, and make sure that it is trimmed 3 to 5 mm. shorter all around its periphery than the edge of the finished impression is expected to be. Make a mark on the patient's palate with a copying pencil 5 mm. back of the point where movement begins when the patient utters the sound "ah." Trim the posterior border of the tray so that it will not extend beyond this point. If the patient gags easily, it may be cut off 2 or 3 mm. shorter.

Preparing the Compound.—Soften a cake of compound in water at a temperature of approximately 70° C. Above 80° C. the compound is not only too soft to work to good advantage, but its quality is permanently impaired, and continued heating at such high temperature makes it granular and brittle and totally unfit for use. Smear the inside of the tray with the end of a stick of compound heated in the Bunsen or alcohol lamp flame to the point where it just begins to sizzle, then for the average size mouth, immediately place on the tray about two-thirds of the cake of compound. Shape the mass with moist fingers to the approximate shape of the jaw, pass quickly over the flame to glaze the surface and dip in the hot water to prevent it sticking to the tissues, and insert in the mouth in the same manner as for plaster, press to place gently, not with enough force to cause the high points to cut through the compound to the tray, but aim to leave an intervening thickness of compound of about 3 mm. Hold steadily in position until the compound is sufficiently hardened so that it will not become distorted in removal by coming in contact with the lips or corners of the mouth, and immediately after removal place in cold water and allow it to harden thoroughly.

Note.—It is advisable for difficult cases to take an imprint of the cast with the softened compound in the tray, allow it to chill, then soften the surface by dipping in hot water and insert in the mouth. This aids materially in properly positioning the impression, and avoids a surplus of compound.

"Tracing on" Compound.—After trimming off surplus compound with a sharp knife wherever the edges are too thick, or lapped over the tray too much, dry the impression with a towel. Heat the end of a stick of compound until it will flow readily, but not to the sizzling stage. Heat the edge of the impression at any place where it is deficient with the small flame of the mouth blowpipe, and dab on the softened compound from the end of the stick, "tracing" or directing it where desired.

Modifying the Periphery.—Wherever traced-on additions have been made, it will be necessary to readapt and modify the periphery as well as at other points where folds may occur. To do this, soften the edge with the mouth blowpipe, dip in hot water, insert the impression, and hold in place firmly with the first two fingers of one hand under the palatal part. With the forefinger of the other hand gently roll the softened compound up against the tissues at the base of the ridge, then gently press the cheek or lip against the compound in the softened area with the thumb or the palm of the hand, allow time for cooling, then remove from the mouth and chill in cold water.

Muscle or Tissue Trimming.—When the periphery has been modified as above directed, it is likely that it will be too high at some points where bands of tissue are attached to the base of the ridge from the lip and cheeks, and will have to be trimmed to permit free movement of these tissues, which is best done by having them cut into the softened edge of the impression either by manipulation by the operator or by the voluntary muscular movements of the patient. Beginning at one tuberosity, carefully soften about one-fourth of the periphery with the mouth blowpipe, but avoid heating any other part, dip in hot water and quickly insert in the mouth. Have the patient produce all possible movements of the facial muscles, or the operator may to better advantage in most cases draw the cheek or lip of that area over the edge of the impression to modify it as his judgment indicates. Proceed in a similar manner until the opposite tuberosity is reached, taking in about one-quarter of the periphery each time.

Considerable care and judgment is required in this step. Having the compound too hot will cause it to melt and flow out of shape, while if it is not soft enough, too much force will be required to make the tissues cut into it, and their imprint will resemble that of a tightly stretched string.

To prevent too much pressure on the muscle attachments just back of the tuberosities, caused by the impression being too high at these points, soften the edge with the mouth blowpipe in this area on one side of the impression, place in the mouth, hold firmly, and have the patient open the mouth as wide as possible two or three times. Repeat in the same way for the opposite tuberosity.

Refitting the Palate.—After all the foregoing manipulation with frequent reinsertions, it is likely that the palatal part of the impression will bear with greater pressure than other parts. To correct this, heat the entire palate portion with the mouth blowpipe or waxing torch to a slight depth only, dip in the hot water, quickly place in the mouth and hold with firm steady pressure of fingers under the tray on both sides in the bicuspid regions until cooled, then remove and chill. Trim off all surplus so that the entire periphery will present a rounded smooth edge about 3 mm. thick.

Posterior Beading.—Roll a small piece of carding wax (used for mounting artificial teeth for sale) between the hands until it is reduced to a diameter of about 2 mm. Press this lightly to place along the posterior border of the impression, carrying it to the point on each side where the fibrous attachment to the tuberosity occurs. Warm the roll slightly by passing it through the flame of the burner, insert the impression and carry to place with a firm pressure.

Testing for Leaks.—With a small amount of water in the impression, insert it in the mouth and make intermittent pressure on it, alternating from side to side in the first molar regions, and from each tuberosity to the anterior part and back again. Watch carefully for any bubbles that may appear around the edge, and wherever this occurs, trace on more compound, readapt and test until it is certain that no leak remains at any point.

Such an impression would now be considered as finished by those who advocate the use of compound alone for edentulous impressions, and if made by a skilful operator sufficiently experienced in this method would yield good results. In the hands of a student or other operator of limited experience, the impression at this stage might have many defects overlooked or perhaps ignored because of a misleading effect of so-called "suction." Suction in itself, either in the impression or in the denture made from it, is not sufficient to insure the lasting or stable retention of the denture. Therefore, as a final step it is strongly advocated that the compound impression be finished with plaster, given a "plaster wash" as it is commonly termed, thus utilizing the superior qualities of plaster for correcting surface adaptation and copying fine detail.

Finishing Compound Impressions with Plaster.—Mix impression plaster to a creamy consistency, using warm water and an accelerator, pour it or brush it into the compound impression until it covers the entire surface, then give the impression a sharp fling to throw out all but a thin coating. Insert in the mouth and seat with a rocking motion to force out all surplus plaster. Draw out the lip and cheeks so that no folds will be left along the periphery. Instruct the patient to sit erect or lean forward slightly and to relax the cheeks and lips as much as possible. For an upper impression, stand back of the patient and hold the impression firmly and steadily in place with the fingers under the tray on both sides in the bicuspid and molar regions. For a lower, stand in front and at one side of the patient and hold the impression with fingers above the tray and thumbs under the mandible. Keep the impression in place until a test of the plaster left in the bowl indicates thorough setting by showing a clean fracture when a piece is broken and until moisture cannot be readily expressed from a small fragment crushed between finger and thumb. It is well to use a time factor, which avoids uncertainty and makes tests unnecessary, thus leaving the hands free to hold the impression steadily throughout the period determined upon. It has been found that if the impression is held in position for two minutes and then allowed to remain in place without pressure, undisturbed by patient or operator for a further period of three minutes, this procedure provides sufficient time for setting as described above and enough latitude to cover variations in several different brands of plaster with which it has been used.

Removing the Impression.—Such impressions as have just been described are usually difficult to dislodge, and every effort should be made to get them out without breaking away small fragments around the edges. In removing the impression, have the patient assist by puffing out the cheeks, and if necessary use the water syringe to direct a stream of water around the edges, or if compressed air is available use it in the same manner, which is the best means of all for this purpose. After removal, wipe away the saliva and any small fragments of plaster from the surface of the impression with a tuft of cotton, but do not wash in running water, and if possible, as soon as the plaster appears dry and free from surface moisture, immediately prepare the impression for pouring the cast.

Lower Impression.—The procedure for the lower impression is very similar to that just given for the upper, but a few differences are to be noted.

Shaping the Tray.—After the preliminary impression has been taken and the cast made, the tray should be fitted and conformed approximately to the anterior part of the ridge, as for the upper, and trimmed about 4 mm. shorter than the edge of the finished impression is to extend. At the posterior portions of the ridge, the tray is made to extend well down on the lingual side and trimmed quite narrow on the buccal side to allow for the free manipulation of the compound in this region with the fingers. The tray is made to conform in a general way also to the curve of the ridge from the median line backward.

If the shape or size of the ridge and arch are such that no stock tray can be readily adapted and made to cover the denture area, especially in the posterior lingual part, it is best to form on the model a wax tray pattern including a handle and to reproduce it in vulcanite or by an aluminum casting. The latter is to be preferred, as it can be more quickly done with a minimum of attention to fine details. The time thus spent can be saved in the actual taking of the impression, with superior results in its accuracy.

In attaching the compound, proceed as for the upper impression, and make it a rule to take an imprint of the cast as suggested for the upper. In very simple cases only, with well defined regular ridges, omit the preliminary imprint of the cast, and proceed by working the compound in the tray into an approximate shape and insert it directly into the mouth. Settle the impression to place gently, rotating slightly, or moving forward or backward, as indicated, in order to give it a correct position. During this first insertion, make no effort to manipulate the compound with the fingers, as this tends to make the impression rock. Simply hold it steadily in position until hardened, then remove and chill. Make all necessary additions and modifications after this first step, and maintain an even bilateral pressure during all manipulation in the mouth.

Determining the Periphery.—The position of the outer periphery of the lower jaw from one ramus to the other must be almost wholly determined by the operator by finger manipulation from the outside, placing little or no reliance on the patient's voluntary muscular movements. Where the impression crosses the ramus and around the posterior lingual border to a point about 15 to 20 mm. toward the front on each side, the position and length of the edge of the impression can best be determined by means of finger pressure *inside* the mouth, and careful observation as to any interference with the tuberosity of the upper. The remainder of the lingual periphery anterior to the region of the second molar on each side usually can best be formed by the patient's muscular movements.

Tongue Movements.—Soften the edge of the impression lingual to the region of the six anterior teeth in the flame as for the upper, dip in hot water to equalize temperature and carry quickly to the mouth. Have the patient immediately protrude the tongue and move it from side to side. Several attempts may be necessary, as the patient has a tendency to protrude the tongue too far and to use too much force.

Proceed similarly, one side at a time, with the lingual region from the cuspid position to that of the second molar. In this area, have the patient first thrust the tongue forcibly into the cheek on the side where the modification is being made, then carry the tongue to the opposite side, as each of these movements produces a different muscular action at the base of the tongue. Trimming or adding is necessary from time to time, in order to secure a rounded edge and the proper thickness (about 2 to 3 mm.). Finally, before the plaster finish is applied, soften the inner edge slightly from the position of the second molar on one side to that on the other, insert, and have the patient very quickly and forcibly suck the tongue against this area. In many cases this will produce a peripheral lingual adaptation which is almost ideal and will go far toward securing so-called "suction" on the lower denture.

Test for bubbles as in taking the upper impression. Test also for muscular dislodgment by having the patient speak several sentences, or read aloud, watching to see if the impression follows the mandible in its movements or is lifted by the lingual or buccal muscle or tissue attachments. If so, go around the periphery again and make modifications in areas that appear to be overextended, softening small portions at a time and by means of the same manipulations by operator and patient as have just been described. Much care and judgment must be used in determining the limits of the impression around the ramus and at the posterior lingual border. If a pronounced mylo-hyoid ridge be present, with the summit of the alveolar ridge at nearly the same level, the impression should not extend below the mylo-hyoid ridge, but should be carried well onto the ramus posteriorly. On the buccal aspect, the edge of the impression should be reduced so that it is not easily felt by passing the hand over the cheek perpendicularly.

If the operator is satisfied that the peripheral border is correctly developed, and the impression withstands the tests reasonably well, it is now ready for the plaster finish. This is to be done in the same general manner as previously directed for the upper impression, except that every effort should be made to have the plaster mixed to such a consistency that it will set as promptly as possible after being carried to the mouth and settled to place, in order to prevent portions of the plaster around the edges being washed away by the more plentiful supply of saliva present and the movements of the tongue the patient is likely to make before setting is completed.

Follow the same procedure as directed for the upper in holding the impression steadily in place under pressure for a specified time and also allowing sufficient total time for complete setting of the plaster before removal from the mouth. It is even more necessary to hold the lower impression in place and also to hold it for a longer time than for the upper because of the reasons just mentioned.

After removal the lower impression should be treated in the same manner as directed for an upper impression by cleansing its surface without washing in water, and by beginning to prepare it for pouring the cast as soon as the plaster has dried out sufficiently to receive the separating varnish.

CHAPTER IV.

CASTS AND MODELS.[1]

By EDWIN H. MAUK, D.D.S.

TREATMENT OF THE IMPRESSION PRELIMINARY TO MAKING THE CAST.

Following the taking of the impression, the *negative* imprint of the parts for which the prosthetic appliance is to be made, the next step in the procedure is to produce the cast from it, the purpose for which the impression was made.

When the cast is made and finally separated from the impression, it constitutes the *positive* reproduction of the parts, the surface upon which the denture is fashioned, or the model or pattern from which dies are made, which in turn are used in the process of shaping the base-plate, the original cast remaining as a test or proof of the accuracy of the resulting product.

What has already been stated is again emphasized: The preparation of the impression and the making of the cast should be carried out as soon as is practicable after taking the impression.

Plaster continues to expand for some time after its initial set, especially the quick-setting plaster used for impressions; compound is subject to warpage, especially when in a mass of varying thickness at different points and in a state of tension, as when chilled in the mouth after being formed to shape while soft and warm. In either case the impression is apt to be injured by accident or by handling in spite of all precautions.

While the errors due to warpage or expansion may not be in themselves of great magnitude, they are added to other errors incident to the processes involved in making the denture, and as there is nothing to be gained by delay, it is well to take advantage of this opportunity to eliminate even a small percentage of error at no greater cost than that of prompt and intelligent procedure.

With nearly all impressions, some preliminary preparation is necessary before the cast can be made. This varies according to the type of the impression and the material used but the details of procedure may be grouped under four general heads as follows:

1. Assembling the parts of an impression fractured for removal from the mouth.
2. Scraping or otherwise modifying the surface of the impression.

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[1] See footnote, Chapter III, for definition of cast and model.—Ed.

3. Treating the surface to insure separation from the cast.
4. Surrounding the impression with a matrix for retaining the cast material while setting.

Assembling Fractured Impressions.—When a plaster impression is removed in sections following the removal of the tray, small fragments are chipped off along the edges and at other points, which are of no value or importance in the impression, but adhere to its surface with the saliva, and must be removed at once so that they will not interfere with the fitting of one fractured surface to another. Washing these off with a stream of water softens the plaster, which is not fully set, and the surplus moisture thus added causes delay in waiting for it to evaporate before the assembling can be begun. Brushing them off with a moderately stiff brush is a better method, and an artists' flat bristle brush, about 10 mm. wide, is well suited to the purpose.

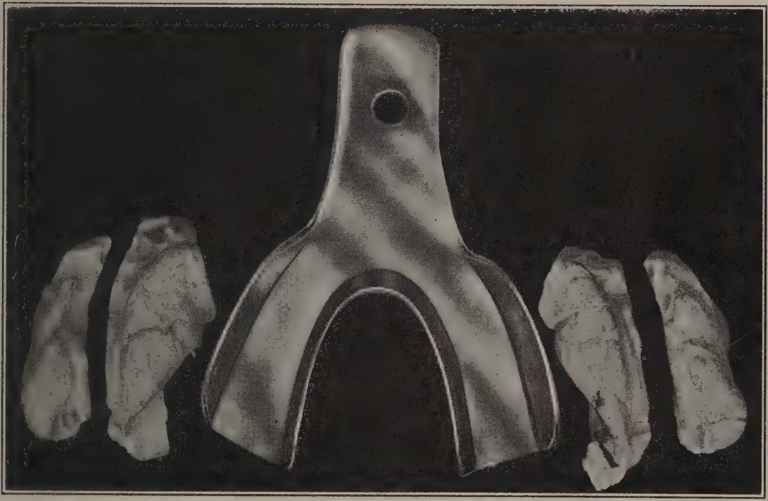

Fig. 78.—Partial lower impression removed from the mouth in sections, ready for assembly on the tray.

After the sections are freed of small particles and surplus saliva, they should be laid aside for a few minutes to allow for setting and the evaporation of surface moisture. Ten to fifteen minutes is usually sufficient. The tray may be used as a guide in which to assemble the parts, but in many instances the expansion of the plaster is sufficient to prevent the impression going back to its original position in the tray, so that it may be more accurate to fit the pieces together by means of their fractured surfaces only, without the use of the tray, though it is true that the tray affords a certain amount of convenience in holding the parts in their approximate relation (Figs. 78 and 79).

Select two of the larger fragments first, see that no small particles have been left along the line of fracture, then fit them together carefully. They should join so perfectly that the junction appears only as a fine line along the surface against which the cast is to be made, unless some small fragment has been chipped from one of the edges. This may be so small as to be of no consequence, or it may be found among the other pieces and inserted later. Hold the sections together, and fasten along the line of junction on the surface originally covered by the tray with a few drops of smooth, molten, sticky wax. (Beeswax with 25 to 50 per cent rosin melted together and formed into sticks for convenience.) With a hot spatula immediately flow the wax along the line of junction thoroughly, as otherwise it will have only a superficial hold and allow the pieces to fall apart easily. Proceed with the remaining pieces in a similar manner until all are fitted and joined. It may be found necessary to temporarily unfasten some large section from the assembly in order to let a small fragment drop into place.

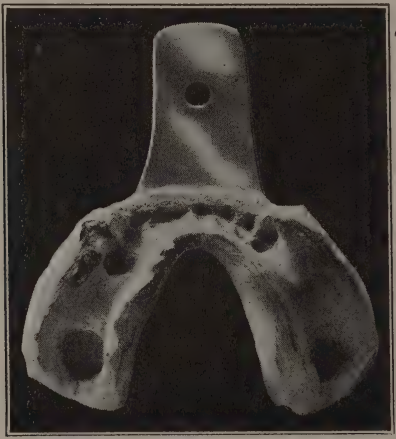

Fig. 79.—Partial lower impression assembled on the tray.

If there are many pieces and the fracture surfaces in contact are small in area, it will be found helpful to reinforce the joints by laying pieces of match-stick or wire across the line of fracture and waxing them securely in position with a considerable bulk of wax. It is well to add such a brace to join the two posterior extremities of a lower impression in all cases.

Scraping or "Relieving" the Impression.—Nearly all edentulous upper impressions and partial ones which cover the roof of the mouth, also many lower impressions in cases where the lower ridge has a thin sharp summit, require scraping. The object sought is similar in each instance, namely, to compensate for the pressure of mastication and the resulting movements of the dentures on their supporting tissues. It has been contended that if an artificial denture has perfect adaptation to the tissues, it needs no relief such as is afforded by scraping the impression or by other means to aid its retention or stability in the mouth. Aside from the fact that adaptation, at best, can be only relative and not perfect, a brief consideration of the conditions involved will serve to show that this statement is subject to qualification.

The alveolar process is a specialized tissue developed solely for the support of the teeth, and when the teeth are removed it has no further function, but becomes resorbed through the action of certain physiological processes which are well understood and need not be discussed here. Pathological conditions often cause the almost total destruction of the process before the extraction of the teeth, thus perforce, causing their removal for lack of support. The rate of resorption following extraction in the interval before dentures can be made, is governed by several factors, among them being the continuation of previous diseased conditions not thoroughly eradicated at the time of extraction, and which delay both the progress of healing and that of resorption; also the bulk and shape of the alveolar process which remains, thick masses with dense external bony plates resorbing but slowly, likewise sharp spicula and continuous jagged edges.

Fortunately it has been recognized that careful trimming and smoothing of the process at the time of extraction, which is simply good surgery, does much to hasten healing and the necessary resorption, and to produce the favorable conditions of symmetrical ridges and uniform surface for the prosthetist.

After healing and resorption have progressed to a stage permitting the insertion of dentures, the process of resorption is much retarded, but continues more or less slowly for an indefinite length of time, probably throughout the life of the individual, so that ultimately the alveolar process, especially the lower, may disappear entirely.

Undoubtedly this secondary resorption is stimulated by the force transmitted in mastication through the dentures to the underlying tissues and, as might be logically expected, is most apparent in the areas through which the lines of force pass, *i. e.*, along the ridges in the axes of the artificial teeth. Though closeness of adaptation may aid in distributing the force of mastication over a wide area, it cannot prevent the intermittent movements of the dentures due to the yielding of the submucous tissues upon which they rest. These movements resolve themselves into two general phases and increase as the resorption progresses. The upper denture tends to rock upon a more or less centralized area of the hard palate, while the lower, owing to the relatively narrow base upon which it rests, tends more to a vertical movement impinging upon the summit of the ridge.

If, therefore, these conditions are anticipated and met to a certain extent by scraping the surface of the impression, which is equivalent to scraping the denture, but more easily done, a *relative* adaptation of the denture is likely to be maintained over a longer period of time, with better stability and more comfort to the wearer. This applies in a greater degree to the upper denture than to the lower, which will usually require refitting about twice as often in the same mouth as the upper. Scraping the impression or providing relief later on the cast requires much care and judgment to insure its being done in the right place and not overdone. It is assumed that in the preliminary examination of the mouth, such features as hard areas and bony growths in the palate in the upper (Fig. 80), and thin sharp ridges in the lower, have been noted and a mental estimate made of the necessity for relief of these areas in the dentures, so that immediately after the impression is taken, with the patient in the chair for reference, this treatment of the impression should be carried out in accordance with the estimate formed. Necessity for relief is greater in moderately arched or comparatively flat vaults than where the vault has a high roof with an angular arch. The occasional case which presents a high vault with sides meeting at a sharp angle, and with a tendency to a groove at the apex, requires that the denture be most carefully fitted into these areas, without relief along the median line, as there is usually considerable difficulty in preventing the entrance of air at the posterior termination of the groove, which would be fatal to the retention of the denture.

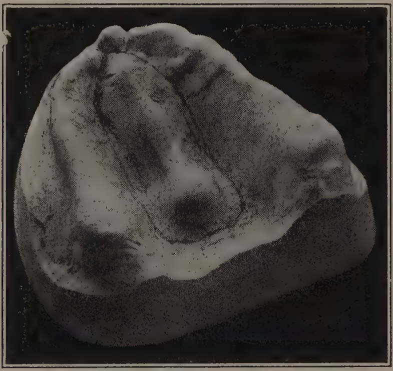

Fig. 80.—Cast of upper jaw with bony prominence. Outline shows area to be relieved.

The area to be relieved in the upper jaw will lie principally along the median portion of the hard palate from the rugæ well back nearly to the point where the hard palate ends and stopping short of the posterior border of the impression 5 to 7 mm. in any event. It will vary with the individual both in width and length, and a good method of determining its limits is to test the roof of the mouth in this region with the rounded end of an instrument handle. By applying gentle pressure along the median line at short intervals, then on either side of the median line gradually working out toward the ridges, noting the extent to which the instrument sinks into the tissues each time, a somewhat irregular area where the hard tissues merge into the softer parts usually roughly oval, will be defined. By sketching this on the impression with a pencil, a convenient guide is afforded of the limits to which the scraping should be carried (Fig. 81). The relief should be greatest along the central portion of the area, from ½ to 1½ mm., at the most, and gradually decreasing to the limits outlined, where it merges with the surrounding surface of the impression.

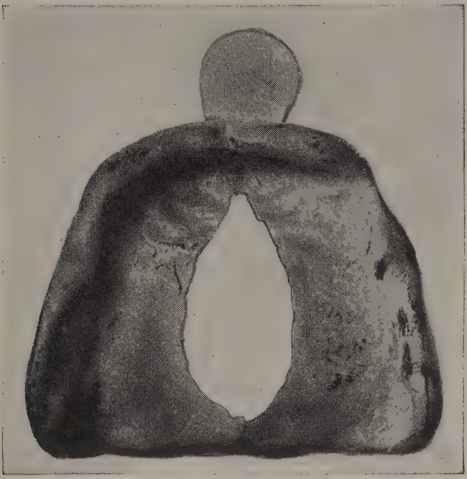

Fig. 81.—A compound impression with central palatine area relieved. (Prothero.)

In the lower jaw the procedure is much simpler. The thin bony ridge, or the thin mass of movable tissue on the summit of a broader ridge, both of which necessitate provision for relief, leave well-defined imprints in the impression, which need merely to be deepened somewhat with a suitable round-edged instrument (Fig. 82).

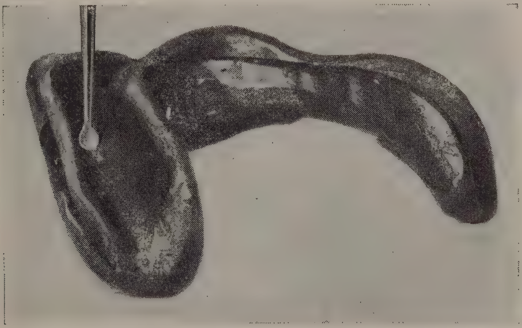

Fig. 82.—Scraping the lower impression to relieve a thin ridge crest. (Prothero.)

It has been found also, in the upper jaw, that where the tissues are thin and tense over the posterior palatine foramina, the pressure of the denture may cause interference with the blood circulation in the vessels which have their exit through those openings, or set up pain reflexes by compression of the nerves, which also issue at these points. When such a condition is revealed by testing with the round-ended instrument, it is desirable to create small relief areas by scraping the impression at the locations corresponding to the foramina.

Separating and Staining Media.—Compound impressions will separate readily from the casts without any treatment or preparation of their surfaces. A coating of light paraffin oil, applied with a brush or cotton swab, and the surplus thoroughly wiped away, will make separation easier and help to prevent sticking if the compound be overheated inadvertently when removing it. Plaster impressions and compound impressions finished with plaster all require treatment of their surfaces with some separating medium to prevent the cast material from combining superficially with that of the impression. For this purpose, two classes of substances are commonly used: (1) Varnishes containing a vegetable gum, which form a surface coating; (2) oils, or soap lather, either of which saturate the surface and render it repellent to the cast plaster.

Soap lather and oil are both rapidly absorbed by the plaster impression so that their effect is soon greatly reduced, if not lost entirely. The varnishing of the impression is more satisfactory in every way, though requiring more time and care.

The varnishes in general use for this purpose are alcohol solutions of the vegetable gums shellac and sandarac, usually used separately, but sometimes combined in one solution. The consistency of the solution is of great importance. If too thin, the solution is absorbed by the plaster to such an extent that several coats are necessary before any surface glaze is evident. If too thick, it is not only difficult to apply, but also piles up on the surface without penetrating the plaster, and may obliterate some important details which should be reproduced on the cast. An aqueous solution of sodium silicate, known as water glass or liquid silex, is also sometimes used as a separating medium, but is likely to form feathery crystals on the surface and to flake off, which renders its use unsatisfactory.

Stock solutions of sandarac and shellac are easily made by tying a quantity of the common commercial drops or flakes, in which form it is obtainable from the dealer in chemical supplies, in a piece of gauze and suspending it in a wide-mouthed bottle, tightly corked, so that it will be immersed in a mixture of alcohol and ether. Occasional shaking will aid solution, which may require several days for completion, and the product will be a clean varnish free from dirt and all insoluble foreign material, which is retained in the gauze bag. Ether, which is not included in the commercial sandarac and shellac varnishes, is a good solvent of these gums and causes the varnish to dry more rapidly when applied to the impression.

Another separating medium of much merit is made by dissolving brown gum shellac in a hot aqueous solution of borax. This is especially useful for separating the two halves of a vulcanite flask, and for partial plaster impressions.

Formulæ for Varnishes.—*Sandarac or Shellac Varnish. Stock Solution.*—

Ethyl alcohol	2 parts
Ethyl ether	2 "
Gum shellac, or gum sandarac	1 part

Enclose the gum in gauze bag, suspend in the solvent in wide-mouthed bottle. Change consistency as desired by adding more gum or more solvent. Keep tightly corked, in cool place.

Borax-shellac Separating Fluid.

Water	120 cc.
Borax	12 gm.
Shellac chips	24 "

Dissolve the borax in the water, bring to a boil, add the shellac slowly, stir until dissolved. Permit solution to settle for several days, then siphon into bottle and keep tightly corked.

In all plaster impressions of partial cases or those including the entire arch of teeth, and which must be removed from the cast by cutting and chipping, some means should be provided for indicating nearness of approach to the cast so that it will not be mutilated by cutting too deeply. This is accomplished either by treating the surface of the impression previous to the application of the separating medium with a staining fluid which will penetrate to some depth, or by incorporating a coloring material with the separating varnish, which should, in this case, first be applied as a very thin solution, followed by other applications of the same material of thicker consistency. The aqueous solution of shellac referred to above serves this purpose very well, having a reddish-brown color; the brown shellac varnish also is quite suitable, and suitable color may be imparted to the sandarac varnish by the addition of a few drops of aniline dye, such as the stains used in histological and pathological work.

Very good results are obtained by first brushing red ink over the impression, which penetrates deeply and produces a strong color, then following with several coats of sandarac of a medium consistency. It is common practice to use one or more applications of thin shellac varnish as a staining fluid, which to a certain extent acts also as a filler without making a surface coating or glaze, and to follow this with sandarac of heavier consistency, which imparts the desired glaze with the minimum amount of surface coating.

The varnishes may be applied to the impression with small cotton swabs, but brushes are more convenient, and permit a more even distribution on the surface. Two sizes are needed, a small one about

2 mm. in diameter, for carrying the varnish into deep imprints of the teeth, and a larger one about 5 mm. in diameter for the broader surfaces (Fig. 83). They should not be used for any other purpose, and it is essential that the brushes and the varnish solutions be given a certain degree of care to prevent evaporation of the liquid and to insure that the brushes will always be ready for use.

The best plan is to provide a separate bottle with a ground glass cover for each solution in which to keep a small supply ready for use. Such bottles may be obtained of the dental supply dealer in various sizes. The size holding about 50 cc. is suitable for the working supply to be kept on the bench, and it is convenient to keep the brushes provided for each solution in the bottle when not in use, suspended in the solution but not resting on the bottom, which would bend the brush out of shape permanently and make it practically useless. By smearing the outside of the ground joint surface on the bottle with vaseline, sticking of the cover will be prevented should the varnish accidentally get in the joint and the volatile solvent will be better protected against evaporation (Fig. 84).

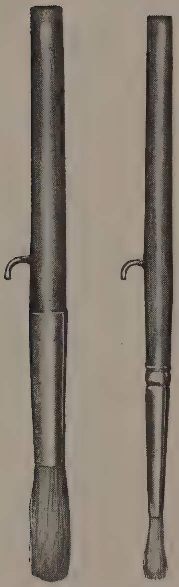

Fig. 83.—Varnish brushes with wire hooks for hanging in bottle.

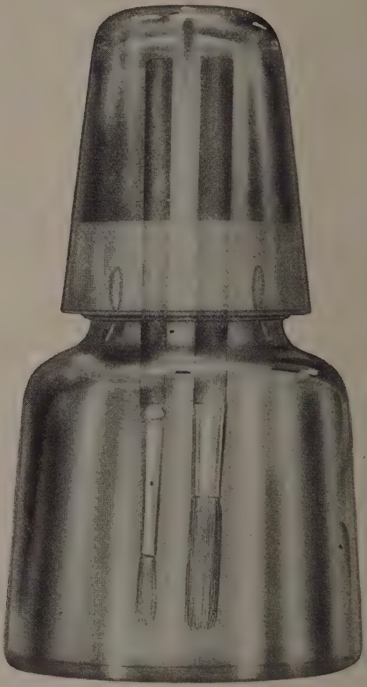

Fig. 84.—Varnish bottle with brushes hanging on wire support.

Boxing the Impressions.—Whenever hard plaster or a plaster compound of the slow setting type, which may require several hours to attain its complete set, is to be used for the cast, it is highly desirable if not essential, to provide a matrix or wall surrounding the impression to facilitate the filling in and packing of the cast material, as well as to retain it while setting and to give proper form to the cast.

This procedure is usually termed "boxing" the impression, and should be carried out with all edentulous impressions or extensive partial impressions if slow-setting plaster is to be used. With ordinary plaster it will be found a great convenience, but is not so essential.

The material for forming the matrix may be wax in sheet form, or what is better, some strips of thin sheet lead or tin should be provided and kept for this purpose, as they may be used repeatedly, and easily cleaned of plaster and straightened out each time for future use. The strip either of wax or metal must be long enough to entirely surround the impression, with an overlap, and wide enough to make a wall standing above all parts of the impression, so that the cast when formed level with the top of the box, will not be less than about 8 mm. thick in the vault portion of the upper, and at least twice that thickness in all the ridge parts of the lower.

To apply the wax matrix: First warm some of the soft black carding wax on which artificial teeth are sold and form it into a roll about 4 mm. in diameter. Carefully attach this roll to the outer edge of the impression by pressing it to place and slightly melting the edges of the roll with a hot spatula if necessary, so that it will follow the curve of the periphery about 3 or 4 mm. below the crest.

On the upper, carry it across the posterior border in the same manner so that the entire rounded edge is left exposed. On the lower, the lingual space should be filled in or floored with a piece of sheet wax cut to fit, and attached by melting the edges on the under side with a spatula, so that the entire length of the lingual edge of the impression is left exposed the same as the outer edge, about 3 or 4 mm. Now form the matrix strip around the impression by bending and pressing to place with the fingers, and lap the ends. Secure the lap joint with sticky wax, and also attach the matrix similarly to the wax roll and to the impression at suitable points along the line of junction on the under side of the impression, and fill in any spaces where plaster might run through. A mold or box is thus formed with continuous walls held away from the impression a short distance and leaving all edges free for reproduction on the cast, and which may be conveniently handled and jarred on the table if necessary in settling the cast material to place. It has been suggested for greater security that the under side of the box be filled in with quick-setting plaster before filling the impression, but this is not necessary if reasonable care is used in handling the mold, the wax box itself being fairly rigid.

With a tin or lead matrix strip, a somewhat different method should be followed, which also insures greater safety of the impressions in handling and in packing with the casting material. Make a thick mix with quick-setting plaster, and heap a mass of it on a piece of paper or on a glass slab. Sink the impression, previously given at least one coat of sandarac varnish, into this mass, tray side down, and shape the plaster up around the sides of the impression, but not approaching its periphery, and with special care to prevent plaster from encroaching on the posterior borders of either an upper or lower impression. As soon as the plaster sets enough to permit cutting it, trim it to form a flat base, with vertical sides extending not more than 3 mm. beyond the outer sides of the impression, and with a straight line, not concave, across the entire posterior aspect.

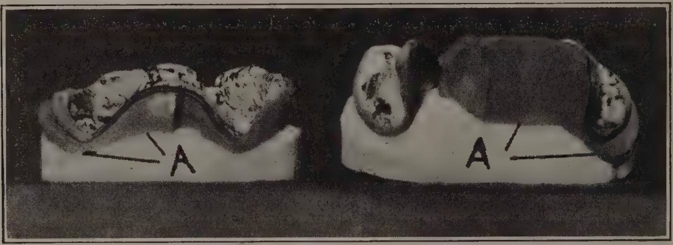

Fig. 85.—Upper and lower impressions, posterior view. One-half of each impression has plastine (A. A.) built up to the peripheral border. The other half shows the relations of the plaster base and the impression.

Next with a small roll of plastine or plasticine,[1] fill in and build up the sides of the base to within about 3 mm. of the crest of the periphery all around the impression including the posterior borders. Trim the

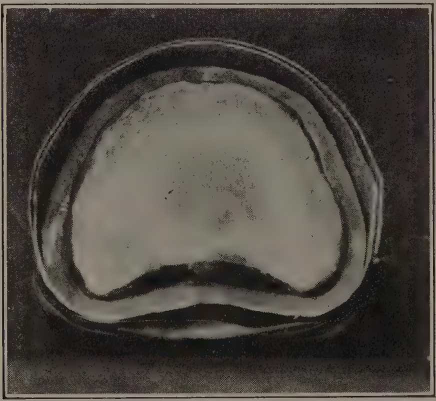

Fig. 86.—An upper impression with the plastine border and the matrix of sheet tin held in place with a rubber band. The posterior part of the matrix is cut away to afford a clear view.

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[1] A modeling clay used by sculptors prepared with an oil medium. Moldine used in the dental laboratory is not suitable for this purpose. The hygroscopic property of the glycerin medium with which it is mixed causes it to abstract the water of crystallization from the cast material wherever it comes into contact with the cast, and leaves the edges of the cast soft and chalky.

upper edge of the plastine flat and make its sides flush with the edges of the plaster base (Fig. 85). Now wrap the matrix strip (40 x 400 mm. $1\frac{1}{2}$ x 16 inches) around the plaster base, beginning at the middle of the posterior surface and secure it with a rubber band or a piece of string (Fig. 86). Apply one or more coats of varnish over the entire surface of the impression and the plastine, and when this has dried, proceed with pouring or, more properly speaking, the packing of the cast.

Cast Materials.—For all record casts of orthodontia cases, study "models," and casts which are to be used as patterns for sand molding in making dies, and for many small impressions in crown and bridgework, the ordinary plaster sold by the dealers as flasking plaster, serves the purpose very well. It has also long been the standard material for casts upon which to vulcanize partial and full dentures, but recognition of its objectionable quality of expansion, and the need for a material of greater resistance to crushing strain in the vulcanizer, have led to investigation and experiment with other substances and with modifications and combinations of plaster, which have recently displaced flasking plaster to a great extent for this purpose.

The use of a slow setting coarse building plaster has also been advocated for this purpose, and for embedding the cast in the flask when vulcanizing, apparently following out the idea which has been more or less prevalent among the profession, that all slow setting, coarse plasters are superior in hardness, without taking into account the factor of expansion, but it is doubtful if such a plaster possesses any marked advantage in resistance over a good grade of dental flasking plaster when exposed to heat, moisture and pressure in the vulcanizer.

Two types of plaster compounds or modifications have been developed for casts and have attained quite general use for this purpose. One is a combination of plaster with Portland cement, together with a certain amount of sand for a binder, and a retarder to control the setting of the plaster. Spence's plaster compound, according to analysis, is of this type, and has been shown by various tests to have a high crushing resistance, both in the dry state and in the vulcanizer, and a low expansion index.[1] The presence of the sand makes it somewhat difficult to cut and trim the casts, and this together with its very slow setting makes it objectionable to some prosthetists.

The other modification consists of an "overburned" plaster, as it is known in the trade, with an accelerator added to hasten setting, and in some cases other substances to modify the color or facilitate mixing. Weinstein's and others, so-called "artificial stone" according to analysis, are of this type. Tests made of these plasters also show a low expansion and a crushing resistance relatively high though somewhat inferior to that of the material with the sand as a bonding agent.[2]

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[1] Research conducted at the University of California; reported in part by E. H. Mathis (A Study of the Behavior of Plaster of Paris, Jour. Natl. Dental Assn., 1919, pp. 432, 445).

[2] Ibid.

Their comparative ease of working, moderate setting time, freedom from grit, their hardness and fineness of texture make them the choice of many prosthetists for casts for general purposes including those for vulcanite work. Tests made under actual vulcanizing conditions of heat, moisture and pressure show that this type of plaster has ample crushing resistance if excessive pressure in the flask press is avoided and vulcanizing be carried on carefully at moderate temperature.[1]

Another material of different nature from the above, considerably used in building work, and known as Sorel cement or Sorel stone, has also been utilized for casts for dental work. As the name indicates, it is a dense stone-like substance when fully set, so hard that it cannot be cut with a knife, and can be trimmed only with difficulty by means of a coarse file or carborundum stone.

Chemically it is known as magnesium oxychloride, and is a crystallization product of the mixture of magnesium oxide with a saturated aqueous solution of magnesium chloride, that used for dental work usually having a quantity of quartz sand added as a bonding material and to give the mass consistency and stiffness when mixed.

It is said to have practically no expansion compared with plaster and to withstand a crushing strain of approximately 5000 pounds in a cube of 1-inch section (Prothero).

Its use for vulcanizing casts is highly advocated by some workers, and its great value for this and other dental purposes is unquestioned. The comparative complication of its preparation and chemistry, the difficulties involved in its working, and in finally removing it from dentures where any undercuts are present have prevented its use in dentistry to any great extent.

Pouring the Cast.—Pouring the cast, as the filling of the impression is commonly termed, is a misleading expression, since no plaster for a cast should be mixed so thin as to permit its being poured from the bowl or to find its place in the impression without jarring or packing by some other means, for in that case the resulting cast would be so friable and weak as to be of little use.

The best consistency of a plaster mix for a cast can only be determined by experience with the setting rate of the plaster being used and with the purpose for which the cast is intended. A working basis for the ordinary plaster-water ratio is 2 parts of plaster to 1 of water, by bulk, subject to modification as indicated.

The water should be placed in the bowl first, the plaster added by sifting or by sprinkling from the spatula or a spoon, and the mix stirred only enough to combine the two without leaving any plaster unsaturated. Excessive stirring, or an excess amount of plaster interferes with the proper formation of the crystalline structure formed in setting, causing reduced strength or excessive expansion.

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[1] Research conducted at the University of California; reported in part by E. H. Mathis (A Study of the Behavior of Plaster of Paris, Jour. Natl. Dental Assn., 1919, pp. 432, 445).

For the plaster compound and the "artificial stone" products specific directions are furnished by the manufacturers, which should be explicitly followed to secure the best results.

Before filling a plaster impression with plaster compound or artificial stone, it should be thoroughly saturated with water, otherwise it will be likely to abstract some of the water of the cast material which is needed for crystallization, to the consequent detriment of the cast surface. This is most likely to occur with partial impressions at points where the varnish coating may not be thick enough to be waterproof. The same precaution should be taken when making an ordinary plaster cast, as the presence of a small amount of moisture on the surface of the impression helps to flow the plaster into small depressions without forming bubbles.

To make an ordinary plaster cast, a most convenient and practical method is as follows: Saturate the impression as just mentioned and throw out all surplus water from its interior. Have at hand a glass slab and a small stiff bristle brush. As soon as the plaster is mixed, carry a small amount to the impression with the brush and paint it on the surface, aided by the small amount of water left there, or if necessary dip the brush in water to make a mixture which will flow. Work into the deep parts first, such as the imprints of teeth, and immediately follow up with successive small additions of the plaster, jarring the impression frequently, so that the stiffer additions of the normal mix from the bowl displace the thin coating painted on at first, without the formation of bubbles. As the plaster begins to show signs of stiffening, fill in with the spatula and build up to somewhat more than the desired thickness for the cast. As the initial set begins, invert the cast on the glass slab, and smooth up its sides with the spatula, trimming away any surplus parts as soon as the plaster is hard enough to permit doing so without smearing, then allow it to remain undisturbed and set thoroughly.

Although the artificial stone products require to be mixed to a much stiffer consistency than ordinary plaster, it has been found that they may be successfully filled into impressions in the same manner, by adding very small portions at a time and with continuous jarring, until the desired thickness is secured or the matrix filled up.

A very effective method of producing the jarring action is by means of vibration obtained from an eccentric wheel on the polishing lathe.

A "bump" wheel for this purpose is easily made by cutting off part of the wooden hub of a discarded polishing brush, thus producing a flat surface. Put this on the polishing lathe mandrel, run the motor at a low speed, and hold the boxed impression on a flat object, such as a piece of board, a tin can cover, or a glass slab, which in turn is held in contact with the revolving flat-sided wheel while placing small portions of the plaster mix in the impression. This causes the cast material to flow into place rapidly and smoothly, eliminating air bubbles, and produces dense hard casts with a smooth surface.

Spence plaster compound must be worked at almost putty-like consistency to obtain the best results, so that it is necessary to actually pack it into the impression in small pieces, tapping each one into place with a blunt instrument and jarring frequently and vigorously to consolidate the mass. It should be left to set undisturbed for several hours, overnight if possible, and it is desirable to allow a similar length of time for the artificial stone mixtures to attain their full set for best results, though some of them may be safely handled and trimmed at the end of an hour, and separated from the impression at the end of three hours.

Removing the Impression from the Cast.—To remove a modeling compound impression it is best to remove the matrix and tray first by dry heat, then soften the impression by immersion in hot water, being careful not to overheat it and make it sticky.

It is then stripped back from the cast beginning at the edges and folding the mass back upon itself, keeping it soft meanwhile by successive immersions in the hot water. Partial impressions with isolated teeth must be handled carefully, and the compound kept quite soft to avoid bringing the teeth away with the mass, which is quite likely to happen if it becomes necessary to use much pressure to bend the edges back.

Edentulous plaster impressions and edentulous compound impressions finished with plaster, when no undercuts are present, may often be removed from the cast by rapping sharply on the impression with the handle of a hammer or by using a light horn hammer in the same way. If the varnishing has been thoroughly done, and the cast is set hard, it will usually drop out, leaving the impression intact. To remove a plaster-finished compound impression with undercuts, either edentulous or partial, requires no different treatment from that described above for softening the material and stripping back the edges.

All edentulous plaster impressions with undercuts, and partial plaster impressions require a different procedure for separation. For the edentulous upper or lower cases this is not complicated, but it is necessary first to cut down horizontally all that portion overlying the ridge or make a deep groove along the ridge portion, until close approach to the cast is indicated by the appearance of spots, or a continuous line of the color imparted by the staining fluid (Fig. 87). This will leave all the buccal and labial section joined to the lingual only by a thin line of plaster along the ridge, which may be fractured with slight force. If now a few vertical cuts are made along the buccal and labial sides, joining with that on the ridge, the point of the knife may be inserted at the edge of the impression to pry off each section separately, usually with little or no trouble. The lingual section of the lower is treated in the same way, and the palatal section of the upper may usually be pried off in one piece by inserting the knife at the posterior border. If the vault is known to be deep, it is best to make a cut along the median line from the posterior border to the ridge and remove this part in two sections. It is always necessary to use care in making the cuts by proceeding slowly and cutting a little at a time, keeping the cut clear of chips and watching for the appearance of the color of the stain, otherwise the case is likely to be mutilated. Soaking the impression in water will make it easier to cut and to fracture the sections from the adjoining parts.

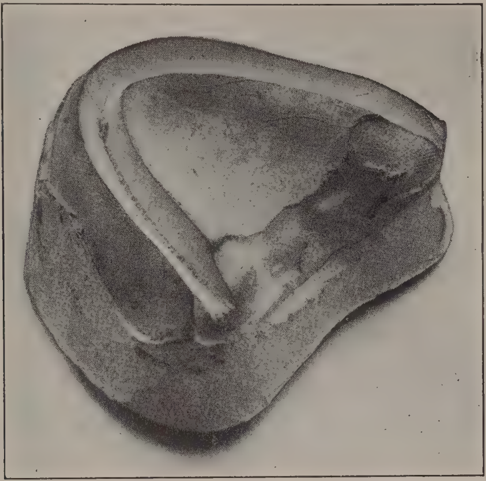

FIG. 87.—Edentulous upper impression and cast. Plaster impression cut down in deep groove to shellac stain.

Partial impressions including both the labial and lingual aspects of remaining teeth are much more difficult to separate, but the procedure is the same in principle, only varying slightly in detail. When cutting down over the line of teeth, isolated spots of color will appear first,

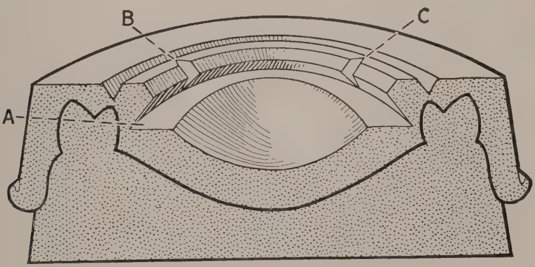

FIG. 88.—Partial plaster impression partly grooved for removal. (Prothero.)

with spaces intervening where teeth are missing. After all the spots indicating the teeth are clearly defined the cutting is continued in the spaces until the ridge is approached, as shown by a continuous line of color in each space. Next, longitudinal grooves are made, one buccally and one lingually at a height estimated as nearly as possible to reach the necks of the teeth at the gingival border (Fig. 88), and finally the vertical cuts both in the outer section and in the lingual part, after which the knife is used to dislodge the numerous small sections thus made. The lines along which the impression was fractured in removing from the mouth will be plainly seen and may be followed to some extent in removing the sections.

Trimming and Shaping the Cast.—The cast usually requires some trimming of its base after removal from the impression, and the base should be shaped in accordance with the purpose for which the cast is to be used. Those which are intended as models for dies should be given a flaring base to facilitate removal from the sand mold with a uniform smooth surface, as the model is to be varnished over all surfaces except the bottom. Models for vulcanite work should have the bases shaped with vertical or slightly converging sides, and their bases should be considerably thicker than those used for sand molding. Orthodontic record casts usually have their bases trimmed with vertical sides converging to a point at the median line for the uppers and following a regular uniform curve for the lowers.

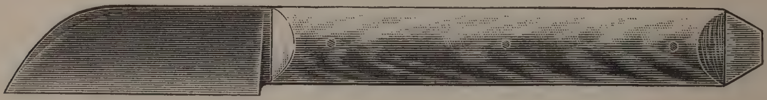

FIG. 89.—Knife with short heavy blade, suitable for plaster work.

Ordinary cast plaster is readily trimmed with a knife having a heavy blade and a straight edge (Fig. 89), together with a small plane where smooth surfaces are desired. The hard cast materials can be trimmed with a knife only with considerable difficulty. For this purpose there should be provided a large coarse flat rasp, and a chisel with a short wide blade used by carpenters and known as a "butt" chisel. The chisel is used to pare off surplus parts of the edge or reduce the thickness of the base while the cast is held securely on a board against a padded cleat to keep it from slipping or having the face mutilated, and the rasp is useful to smooth the edges after they are pared down by the chisel.

It is often desirable to provide relief on the cast when for any reason this has not been done by scraping the impression. The area where relief is needed should be outlined in the same way on the cast, as described for the impression after determining its boundaries by examining and testing in the mouth with a ball-end instrument. A simple and successful method is to burnish successive layers of tin-foil to the cast until the desired thickness is attained.

No. 60 tin-foil, which is approximately 0.005 inch in thickness is ordinarily used for this purpose. The first layer should cover only the central part of the area, each successive one including a larger surface, until the boundaries are reached.

Each layer is fastened down by sandarac or liquid silex as it is placed, so that all edges are covered except that of the last piece. In this way the thickness is graduated from the center outward, and three layers are usually sufficient.

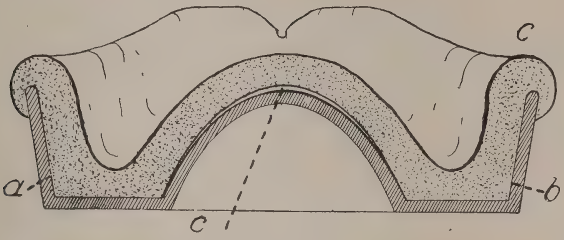

Fig. 90.—Illustrating the manner in which plaster impressions tend to distort when confined by the tray. (Prothero.)

Owing to the expansion of plaster, when the error is doubled if both a plaster impression and plaster cast are used (Figs. 90 and 91), it is good practice to scrape around the periphery of the cast, especially the upper, to compensate for the expansion and to make the adaptation of the denture somewhat more snug along this portion.

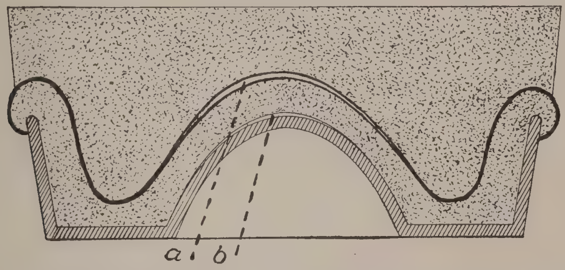

Fig. 91.—Tendency of plaster cast to distort by expansion if confined laterally. Two errors shown at *a* and *b*. If not confined laterally expansion will increase peripheral dimensions. (Prothero.)

The scraping should be very light, not to exceed ½ mm. in depth, and should be done with a round-edged vulcanite scraper which has been ground narrow, so that the blade will not exceed 4 mm. in width at the end. The object is to produce a shallow rounded groove on the cast, not at the crest of the periphery as it will be formed on the plate, but somewhat below the crest, or internal to it, where the slight additional pressure on the tissues is usually borne without discomfort.

Casts for record purposes are usually rubbed with talcum after trimming and smoothing with very fine sandpaper. In some cases when it is desirable to have a distinction between the teeth and other tissues shown by colors applied on the surface, the cast should first have its surface filled with one or more coats of thin liquid glue, or thin colorless sandarac varnish, which makes a suitable surface for the application of oil or water colors.

A similar "sizing" of the surface should always be given to a cast intended for sand molding, followed by shellac or sandarac varnish of medium consistency which will build up a thin coating, practically waterproof, with a high gloss to prevent the sand from sticking.

For vulcanite work, if it is desired to prevent the sticking of wax used in forming a base-plate pattern, or in setting up the teeth, a light coating of liquid silex may be applied while the cast is in a "green" condition, that is, before the surplus moisture has dried out of it, or if it has been standing for some time, it should be soaked and the surface moisture wiped off before applying the silex.

No other preparation of the cast is required at this time and the succeeding steps of the denture construction may be immediately begun upon it.

CHAPTER V.

SECURING ADDITIONAL RECORDS REQUIRED IN THE CONSTRUCTION OF ARTIFICIAL DENTURES. ARTICULATORS.

By CHARLES R. TURNER, D.D.S., M.D.

AND

FRANK A. FOX, D.D.S.

In addition to the casts which represent the jaws of the patient, other data are, of course, necessary for the design and construction of artificial dentures. These casts must be placed and maintained in the same relative position to each other during the subsequent stages of arranging the artificial teeth in occlusion as the jaws they represent are to occupy when the finished dentures have been inserted and are brought into occlusion. We have seen in Chapter I that when the natural teeth are in the mouth the so-called "position of occlusion" is characterized by a certain definite fitting together of the occlusal surfaces of the teeth. When the natural teeth have been lost, the position of occlusion no longer exists, and it is necessary to determine for the mandible, by considerations presently to be discussed, a position in relation with the maxillæ which will answer the requirements of an occlusal position for the artificial dentures. The operation of securing a record of this relationship in accordance with which the casts may be mounted upon an articulator, an instrument designed to maintain them in it, has commonly been called "taking the bite."

Besides the securing of a record of this relationship, it is necessary to obtain also an estimate of the fulness which the artificial dentures must possess to restore the external contour of the lips and cheeks, and to record both the location of the median line of the mouth and the amount of the dentures which will be displayed during the ordinary movements of the lips in laughter and speech.

But it is not enough that the artificial teeth shall occlude properly; they must also be arranged to be capable of functionating to the best advantage during the various mandibular movements in which the food is masticated. This necessitates during their arrangement the use of a so-called "anatomical articulator," an instrument which is capable of reproducing the movements of the mandible of the person for whom the dentures are being constructed. The instrument must be adjusted so that its joint mechanism reproduces the temporo-mandibular joint of the case in hand, and hence the movements of the mandible. A

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record of the path of the mandibular condyles during these movements or its equivalent is therefore necessary. In order that the casts may be mounted upon such an articulator in the same relationship to its joint mechanism as the jaws they represent bear to the temporomandibular joint, a record of this relationship must also be obtained.

As a matter of convenience, it is usually customary at this time to select the shade of artificial teeth suitable for the patient under consideration in accordance with principles to be outlined in a succeeding chapter.

To recapitulate, the data which are to be obtained are:

1. Relationship of the jaws in the position of occlusion.
2. Plane of occlusion or of orientation.
3. Fulness of plates necessary to restore external contours.
4. Median line of mouth.
5. Amount of dentures displayed in movements of lips. (High lip line.)
6. Relationship of the jaws to the temporo-mandibular joint.
7. Movements of the mandible or their equivalents.
8. Shade of artificial teeth.

SECURING THE RELATIONSHIP OF THE JAWS IN THE POSITION OF OCCLUSION.

If it were required to make an artificial denture for an edentulous case immediately after the teeth were lost, and it it were possible to obtain a record of what the occlusal relationship of the jaws was before the loss of the teeth, this would probably serve in many cases for the setting up of the artificial teeth, and the dentures would then establish the mandible in a correct occlusal position. When no data are obtainable which will enable the dentist to tell what this was, and when the changes in the tissues following the loss of the teeth have altered the requirement of an occlusal relationship of the jaws for artificial dentures, an occlusal position for the mandible must be determined by the considerations now to be discussed.

When the teeth have been lost, the position of the mandible is determined by the balance established between the muscles which actuate it within the restriction offered by the temporo-mandibular joint. One characteristic, however, of the occlusal position when the natural teeth remain is that the condyles occupy the most distal position in the glenoid fossæ which they can assume. This distal position of the condyles is one of the requirements for the occlusal position of the mandible for an edentulous case. It is only in such a position that the muscles can be free from strain and the jaw be in a state of equilibrium. This position of the condyles is the ultimate one reached by them from the various movements incident to mastication, and the artificial teeth must be arranged so that when the condyles reach this point the teeth will fit together in proper occlusal relationship.

With the condyles of the edentulous mandible in their most distal position in the glenoid fossæ, only the movement of its anterior end as it is raised or lowered by the muscles has to be reckoned with. This simply means that it has to be established a certain distance from the upper jaw, and this distance is determined wholly by considerations relating to the appearance of the tissues of the face. This latter is the only available guide by which the position of the mandible can be fixed, and it must be such that harmonious contours and proportions of the face are established. Were it possible to keep the condyles in the back part of their fossæ at all times during the determination of the position of its anterior end, it would be simple enough to secure a satisfactory occlusal position for the mandible. It would then be only necessary to hold the jaws apart the amount dictated by a correct judgment of the case in hand when the occlusal position would have been found. But as will be seen later, it is very difficult to get and to keep the condyles back in their fossæ during such manipulations, so it is necessary to solve the problem by a different method. This consists in providing a means of maintaining the jaws a certain distance apart (already ascertained as proper for the case in hand) and then to induce the condyles to slide back to their most distal position. This is the rationale of all proper bite-taking methods.

In securing this relation it is necessary to make use of plates which fit the jaws, and, by affording mutual bearing surfaces, provide a means of keeping them a definite distance apart. If these plates are fixed together while the jaws are in the occlusal position, they thus make a record of it, so that the casts may be mounted in the articulator in accordance therewith. They serve also as a means of recording the other data mentioned above, and as a guide in mounting the teeth. They are called "bite-plates."

BITE–PLATES.

Although the bite-plate performs but an intermediate service and is merely a means to an end, it does not follow that the details of its construction, formation and use are unimportant. As it constitutes a rough model of the future denture, and represents in the detail of its form the specifications of the same, it is highly essential that the greatest care should be exercised in its construction and the greatest accuracy should be observed in registering upon it the various records obtained through its use.

It is absolutely necessary that the bite-plates be firmly retained in place upon the jaws while they are being used, as otherwise it is not possible to secure accurate results in obtaining the several registrations of jaw relationships. While it is advantageous from the standpoint of convenience to employ a material which may be molded into requisite form over the cast without injury to it, neither this nor any other consideration should prevail when the retention of the bite-plate would be adversely affected. Furthermore, since its original form is wholly tentative and must be adjusted to meet the indications of the case, the material used must allow these changes to be readily made and at the same time be strong and hard enough to meet the other requirements.

Bite-plates may be said to consist of two portions, the base-plate, fitting the surface to be covered by the plate, and an occlusal portion, or "bite-rim," as it is frequently called. They may be constructed throughout of the same material, or the two portions may be of different substances. In view of the fact that it is the base-plate which largely determines the retention of the device, and that it is the occlusal portion which may require modification when tried in the mouth, it is obvious that materials possessing qualities suitable to the needs of each portion may be used in combination.

When the future denture is to be mounted upon a metallic base-plate such as a swaged or cast metal base, this base-plate should be constructed first and used for the bite-plate with the addition of a suitable occlusal portion. A thin vulcanite base-plate makes an admirable base. The teeth may later be added to this in a second vulcanization, or if this is objectionable on account of the two vulcanizations required, the great value of the base-plate for bite-plate purposes justifies the additional labor involved in its construction for temporary use only. Bases of soft metal which may be easily swaged have many advantages. They may be of vacuum-chamber metal, of Ash's base metal, of lead or tin, and may be shaped to an artificial stone cast in a shot swaging device with little effort.

Various heat-softened materials possessing considerable rigidity and usually containing gum shellac are also available for base-plates. Ideal base-plate, perfection base-plate and true base may be recommended in this connection. They are readily molded over the cast to an accurate fit, but are slightly brittle and must be handled with care. Modeling compound in sheets of suitable thickness may also be used.

When the impression has been taken in modeling compound, it is the practice of many to use this as the base of the bite-plate. The retentive quality of a carefully made impression is probably better than any bite-plate made over a cast, and its advantage in this connection is apparent.

The bite-rim or occlusal portion should be made of a heat-softened material whose form may be easily altered and yet which possesses sufficient rigidity not to yield under pressure in the mouth. Beeswax is entirely too soft and plastic. Modeling compound or a combination of wax and hard paraffin seem to possess the desired qualities more than other materials, but neither is ideal. Modeling compound has the required stiffness, but cannot be so easily molded or cut when adjusting the bite-plate in the mouth. It is less easy to remove when setting the artificial teeth in their proper positions. The wax and paraffin mixture is more easily molded but is not so rigid as compound.

METHOD OF MOLDING BITE-PLATES IN MODELING COMPOUND.

For the Upper Jaw.—To construct a bite-plate of modeling compound for the upper jaw, the cast should be placed upon its base on the work-bench with the distal portion toward the operator (Fig. 92). The plate outline should have been marked upon it, but any alteration of the face of the cast by additions of tin-foil for retention purposes, should be deferred until a subsequent time, because they would probably be disturbed in the forming of the bite-plate. The method of making the bite-plate in one piece proposed by Dr. W. W. Evans[1] is to be recommended. Three-fourths of a cake of modeling compound is softened in warm water, kneaded in the hands until homogeneous, and rolled into an ellipsoid about 2 inches long. One side of this should be thinned out by pressure between the fingers, and the mass so placed upon the cast that the thinned portion projects slightly beyond the posterior margin of the plate outline. By manipulation with the thumbs the remainder of the compound is gradually worked forward so that the vault of the cast is covered by it to the thickness of about $\frac{3}{32}$ inch. The thickness of this may be readily gauged, for the cast chills the material as it comes in contact with it, thus hardening it, while the overlying soft portion may be pushed forward. When the top of the

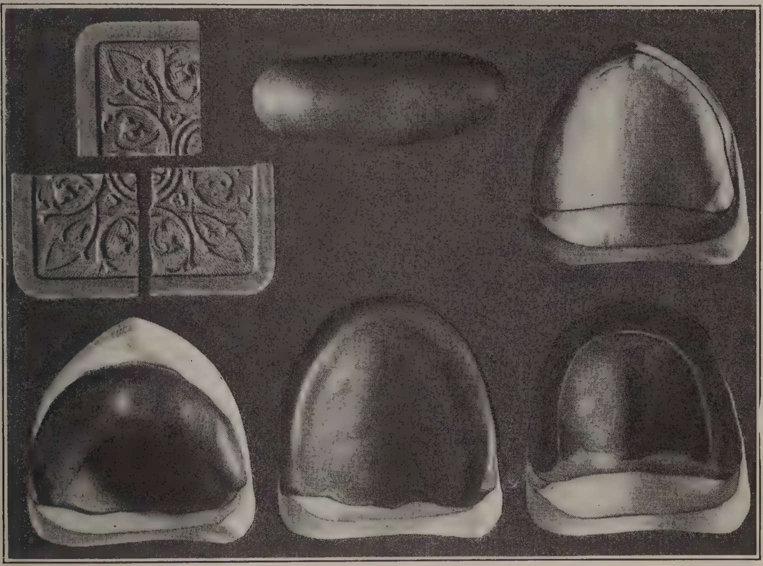

Fig. 92.—Steps in the formation of a bite-plate for a full upper case.

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[1] Int. Dental Jour., vol. **20**, p. 221.

alveolar ridge has been reached, the compound should be carried over it and slightly beyond the plate outline, along the labial and buccal surfaces, the most of the mass, however, remaining upon the ridge and being shaped to represent the occlusal portion of the bite-plate. The probable relation of this part of the artificial denture to the alveolar ridge and the probable fulness of the buccal and labial portions should be borne in mind and the compound disposed accordingly, since the bite-plate when completed should be a rough model for the denture in these particulars. It should be taken from the cast, chilled in cold water, and trimmed around its periphery to the plate outline. It ought then to be replaced upon the cast and its margin brought into close contact therewith, around the plate outline. This is to insure firm retention of the plate in the mouth, which may be further improved by scraping the palatal surface of the plate where it is in relation with the hard median ridge. The form of the bite-plate at this time is largely tentative, as it is purposed to complete its modeling when the bite is taken, in accordance with the requirements which shall then be

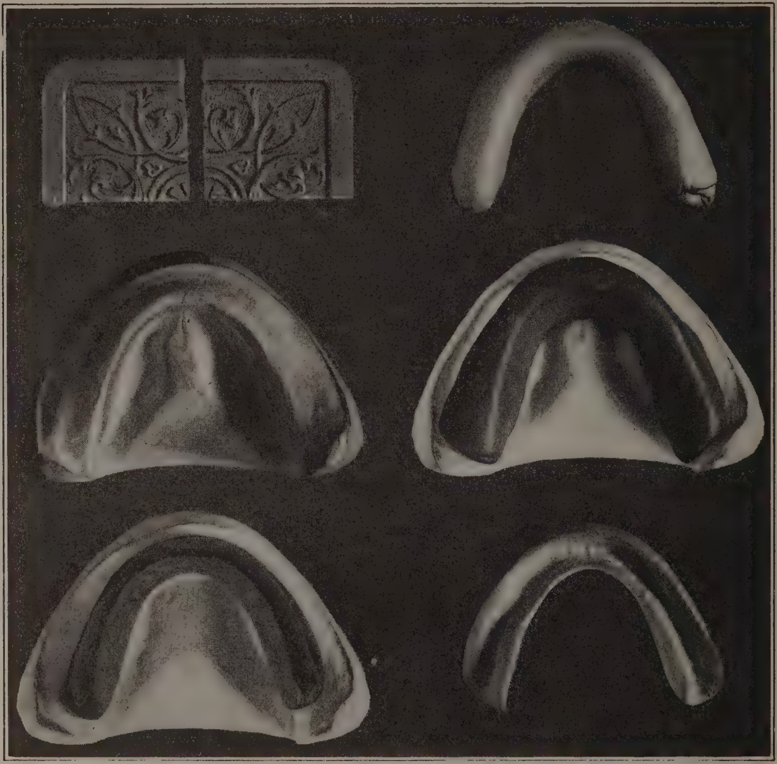

FIG. 93.—Steps in the formation of a bite-plate for a full lower case.

indicated. During the process of forming the plate, to prevent adhesion, the hands should be wet and the compound occasionally taken off the cast to break up its adhesion while it is soft, and then replaced, but under no circumstances must the cast be wet, as this will injure it for subsequent use. Rubbing its surface with soapstone or talcum powder will effectually prevent the adhesion of the compound.

The Lower Bite-plate.—The lower bite-plate is more easily made than the upper. With the cast face upon the work-bench, a piece of compound equal to about one-half of a sheet is softened and worked into a long uniform roll, bent to the shape of the alveolar process, and placed upon its summit (Fig. 93). With the thumbs and fingers it is worked down the lingual and labial sides to a point slightly beyond the plate outline, that portion over the ridge being shaped to represent this part of the future lower plate and made to correspond in outline to the arch of the upper bite-plate. It is removed and trimmed to the plate outline like the upper, its occlusal surface being left rough. If the lower plate must be very thin, it may be strengthened by imbedding in it a piece of iron or brass wire shaped to conform to the alveolar outline.

CONSTRUCTING BITE-PLATES IN TWO PORTIONS.

If a metallic base-plate, or one of vulcanite has already been prepared, after this has been tested in the mouth and proven to be correct as to fit and adhesion, the addition of a bite-rim is then required to prepare it for service as a bite-plate. If a sheet of heat-softened material such as modeling compound or any of the more rigid materials is to be used, it should be gently heated and carefully adapted to the case, its margins trimmed to the plate outline and finally adjusted in the mouth and its retention assured. It then requires the addition of an occlusal portion.

The bite-rim may be made wholly of modeling compound, hard wax and paraffin or of a combination of the two. Modeling compound has the advantage of firmness and hardness, and, as the bite-rim must be stiff enough at body temperature not to yield under pressure between the jaws but to maintain its form in subsequent manipulations, its use is particularly recommended. To form the bite-rim a roll of material about ½ inch in diameter and 4 inches long, very soft and plastic, is molded over the top of the alveolar ridge of the base-plate and fused to its surface. The base-plate should have been placed upon its cast upon the work-bench in a convenient position for the workman. The rim is molded to follow the general outline of the alveolar ridge as described in a previous paragaph. When a modeling compound impression is to be utilized for the bite-plate, the bite-rim must be adjusted with great care in order not to injure the impression, which should be kept cold to prevent change of form. Paraffin and wax is often used in this case because it melts at a lower temperature than the modeling compound base.

An occlusal bite-rim former, illustrated in Fig. 94, will be found useful in quickly molding the rim of either compound or wax and paraffin to suitable form. This former, partly separated, is laid on a clean flat surface. The roll of material, properly softened, is pressed in the former and its two portions pressed together. When the material is sufficiently hardened, the excess is removed with a sharp knife. The resultant rim may then be bent to fit the alveolar ridge and affixed by fusing with a hot spatula.

It is the practice of some to build out the buccal and labial contours of a modeling compound bite-rim with wax, which may be easily molded or carved to give the desired contours when the bite-plates are adjusted in the mouth.

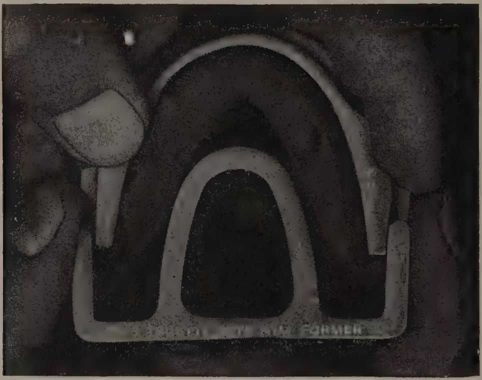

Fig. 94.—Bite-rim former.

Technic of the Operation.—The securing of the relation between the jaws may be divided into two stages—the fitting and shaping of the bite-plates, and the use of them in securing the relation of the jaws in the position of occlusion.

The patient should be seated in an erect position in the dental chair. (Figs. 95, 96). The upper bite-plate is first tried in and the plate outline followed by it verified or corrected if necessary. It is essential to the success of the operation that the bite-plate should remain firmly in position and it should be trimmed where any movable tissues tend to displace it. It should then be observed whether the buccal and labial portions of the plate restore the contours of the lip and cheek tissues which they support, in accordance with principles to be given later, and the plate added to or trimmed as may be indicated. While the modeling in these regions cannot be completed at this stage, it is advisable to have the form answer the requirements of contour as fully as may be possible. The inclination of the occlusal portion of the plate to the ridge may be changed by reheating in water and bending after replacing it upon the cast, or additions may be made to the buccal and labial portions to bring out the proper contour of the lips and cheeks.

A most important point of reference which will be utilized in the construction of the denture and which determines the length of the occlusal portion of the bite-plate is now noted. This is the lower margin of the upper lip when in repose. This should be marked upon the labial surface, and the occlusal portion of the plate trimmed to within $\frac{1}{16}$ inch of this, so that the plate will project that amount below the lip[1] (Fig. 97). After determining the length of the bite-rim in relation to the upper lip, this portion of its occlusal surface should be trimmed so that it is parallel to an imaginary line drawn through the pupils of the patient's eyes. The occlusal plane guide illustrated in Fig. 98 will be found useful in this connection or a thin metal ruler about 6 inches long may be used. The anterior portion of the bite-plate should not be trimmed or added to in subsequent fitting together of the two plates, as the lower margin of this surface is to indicate the position of the incisive edges of the anterior teeth of the artificial denture.

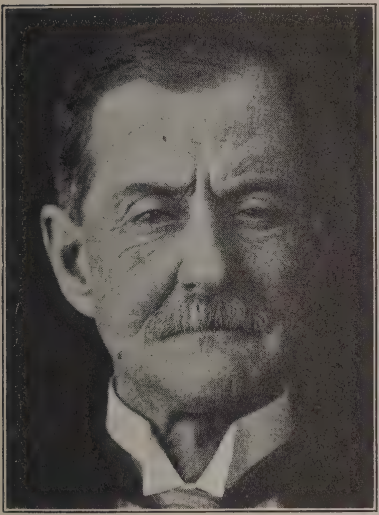

FIG. 95.—Patient without teeth. Front view.

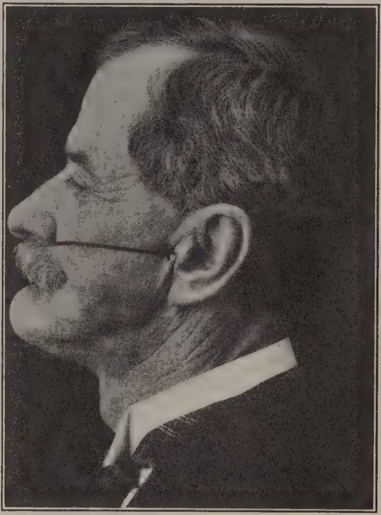

FIG. 96.—Patient without teeth. Side view.

The distal portions of the bite-rim should now be trimmed on each side so that they are parallel to an imaginary line drawn from the bottom of the ala of the nose to the external auditory meatus. In this procedure, the anterior portion previously completed should not be touched, but the trimming should be from this point toward the rear (Fig. 99).

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[1] Dr. A. D. Gritman.

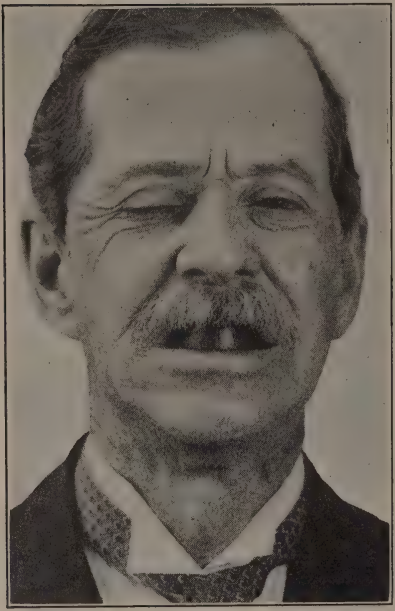

FIG. 97.—Patient with upper bite-plate in position.

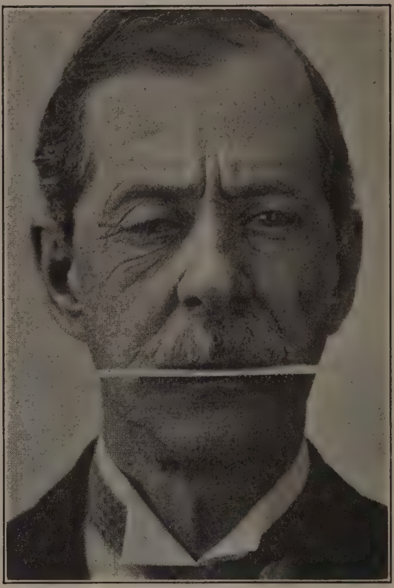

FIG. 98.—Occlusal plane guide, showing parallelism with patient's pupils.

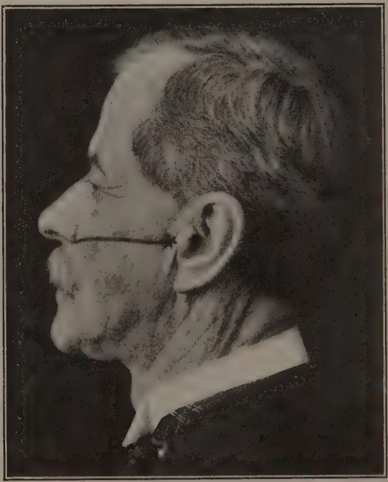

FIG. 99.—Patient with line on face. Side view.

The base lines may be drawn upon each side of the patient's face for guidance, and the occlusal plane guide or ruler should be employed as an indicator to insure that both sides of the rim have been correctly adjusted.

The object of these procedures is to establish at this time the tentative plane of occlusion of the future denture, or as it is has also been called, "its plane of orientation."[1] An examination of Fig. 100, which portrays a face in profile with a superposed photograph of a denture, will show that the general plane of occlusion of the natural teeth is parallel to a plane passed through the anterior nasal spine and the external openings of the two ears. As this is the commonly observed relationship of natural teeth, it furnishes a guide to follow in the placing of artificial dentures.

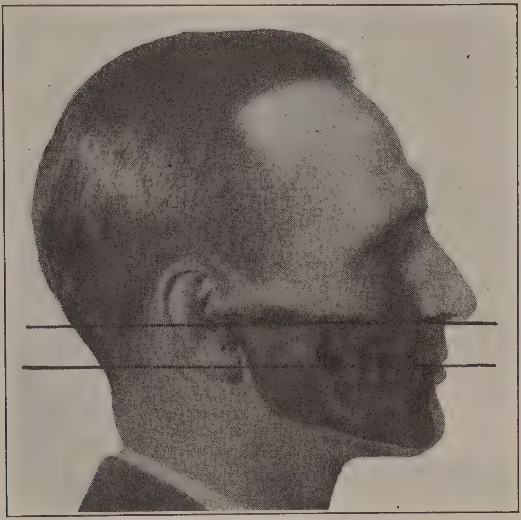

Fig. 100.—Orientation of denture.

It is also to be noted that in the natural dentures the most frequently occurring relation of the upper anterior teeth to the upper lip is that in which the incisal edges of these teeth project about $\frac{1}{16}$ inch below its border when in repose. Incidentally it may be remarked that this relationship is the one of most pleasing appearance. The anterior portion of the bite-rim having been adjusted with the purpose of recording the positions at which the corresponding artificial teeth are to be set, it then remains only to trim the distal portions of the rim so that the plane of its occlusal surface is parallel to the base plane above mentioned. As it is not possible to visualize the base plane but only its intersection with the side of the patient's face, the eyes of the operator should be on a level with the lines on the patient's face to correctly judge the proper position of the occlusal surface of the rim. It must be understood that this flat plane of the rim is only intended to correspond generally to the future plane of occlusion of the teeth. The latter will be curved, whereas this is flat. When the teeth are mounted, their occlusal plane is lifted at the rear from the bite-plate surface, but the measures described locate the upper anterior teeth accurately and indicate in general the spacing of the upper and lower distal teeth between the ridges. They are, therefore, more correctly considered as measures of orientation. Now that the significance of these steps has been explained, the reader will readily understand why it is important not to disturb the occlusal surface of the upper bite-rim once it has been determined, and the necessity of making such adjustments as may be required to make the two plates fit together in the mouth, at the expense of the lower bite-plate.

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[1] Rudolph Hanau.

The lower bite-plate is now tried separately in the mouth, the plate outline verified, and then the two are put in together. The length of the upper bite-plate having been definitely fixed, it is purposed to trim the lower one so that when in occlusion with the upper, when the condyles are in the most distal part of the glenoid fossæ, the jaws will be held apart the distance it has been decided is proper for them.

If it were possible to ascertain what the occlusal position of the mandible was when the natural teeth were in place, it is probable that this would fulfil the requirements of occlusion for the artificial dentures in a majority of cases, although when the teeth have been out some time the tissues of the lips and cheeks have contracted and accommodated themselves to a lessened distance between the jaws. It will be necessary to determine this distance by a judgment based upon the external appearance of the face and particularly that of the mouth, and as this is affected by the fulness of the bite-plates as well as by their length, these two dimensions should be considered conjointly. The tentative form of the upper bite-plate is sufficient guide in the matter of contour to begin with, so the lower plate is trimmed to what is judged to be its proper length, and the contours readjusted subsequently if necessary, or if later alteration of the buccal or labial surfaces should show that the bite-plates are too short, the lower one must receive additions to meet the indications. In judging of the final contours, three places require especial attention: (1) The lips need to be supported at their point of contact, as the margins fall in when the teeth have been lost. This is provided for by the amount of projection of the bite-plate at the point corresponding to the edges of the upper incisors, and by the inclination of its labial surface. (2) As a great deal of resorption has taken place at the site of the canine tooth, this area should be held out by the bite-plate, and the corner of the mouth given proper fulness. The upper bite-plate must be fuller and higher here than anywhere else. (3) The other place at which fulness is often required is at the site of the bicuspids and first molars, where the cheek may be sunken in.

When the labial surfaces of the bite-plates have been built out to proper proportions, the distance between the nose and chin should be such that the lips just come in contact (Fig. 101). When the proper position has been obtained an equal amount of the mucous surface of both lips is displayed, the upper lip is inclined outward slightly from its base, and the lower lip is sufficiently everted to bring out the graceful curve between it and the chin. If the bite is too long, the

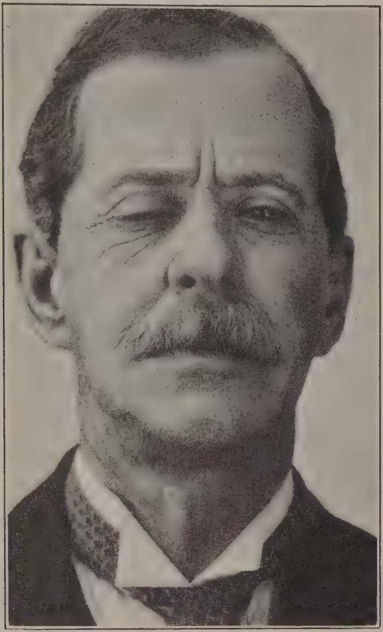

FIG. 101.—Front view of patient with both bite-plates fitted.

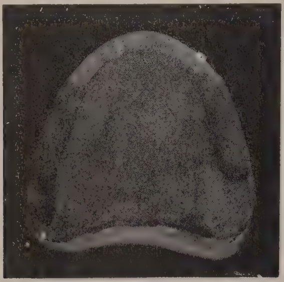

FIG. 102.—Full upper bite-plate, with yellow wax on occlusal surface.

lips will be strained in trying to cover the plates, or if too short, they will appear compressed or curled upon themselves. Where the teeth have been out a long time and where the tissues have wrinkled in consequence, it is impossible to take out all the wrinkles or to establish the ideal contour and proportions above suggested; and this is also true, of course, where they were not originally possessed. It should be remembered that during the fitting and trimming of the plates the condyles of the lower jaw must be kept in their most distal position. When they have once been secured in this position, the lower bite-plate should have its labial surface marked and trimmed or built out until it is flush with that of the upper bite-plate. During subsequent manipulations the relationship of these labial surfaces is a guide as to whether or not the condyles are in their correct distal position. In some cases patients have contracted the habit of protruding one condyle, thus throwing the lower bite-plate to one side. In such instances it will be found advantageous to mark the median line of the face upon upper and lower bite-plates at this juncture, being certain that both condyles are retruded at the time. During subsequent procedures lack of correspondence in these two lines will at once indicate a protrusion of one condyle.

The lower bite-plate must be trimmed to occlude evenly with the upper throughout its whole extent, and when the mouth is closed the contact between the two should be equal at all points. It is important that the bite-plates should be evenly trimmed, since there is danger that they may be in contact anteriorly and appear to be posteriorly, when they are really too short, and have been forced off the ridge by leverage on their anterior portions, and it is wise to leave the lower bite-plate longer behind than in front and trim it to accord therewith. When the plates have been fitted by trimming as closely as possible, an absolute fit may be obtained by removing the lower bite-plate and very slightly softening its occlusal surface over an open flame, quickly returning it to the mouth, and having the patient close in the occlusal position, gently pressing the plates together. It is important that in this procedure the upper bite-plate be kept cool enough not to have its form altered at all. The final fitting may be conveniently judged by placing the index finger of each hand in the mouth in contact with the buccal surfaces of the two plates, which serves to hold them on the alveolar ridges, and by pressing the ball of the finger slightly between the occlusal surfaces of the plates as the patient is directed to close the mouth slowly, they are held apart at places where they do not fit properly. These occlusal portions afford rigid and unyielding surfaces that maintain the jaws apart the distance which has been decided upon. The bite-plates so fitted should now be removed from the mouth. Their occlusal portions should be trimmed down from the inside until they are not more than $\frac{3}{8}$ inch wide. This is to give room to the tongue and to make them as comfortable as possible for the patient. It may be stated that the more nearly they approximate the future denture in form and size, the greater will be the likelihood of accuracy in taking the bite. They should have grooves cut upon their occlusal surfaces, as illustrated in Fig. 103, transverse ones at the site of the first molar and first bicuspid teeth, and a longitudinal one between. The grooves receive the wax to be used later in fixing the plates together.

Having thus determined by means of the rigid occluding surfaces of the bite-plates what the distance between the jaws shall be, the second stage consists in securing the mandible in such position that the plates are in contact and the condyles are back in the glenoid fossæ, and the position of occlusion is obtained. If the bite-plates are then fixed together and taken from the mouth, the casts may be placed in position in them and mounted upon the articulator. The difficulty which presents itself in this procedure is in getting the condyles back in the fossæ.

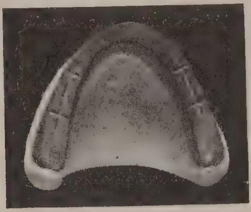

Fig. 103.—Full lower bite-plate, showing grooves cut on occlusal surface.

When the natural teeth are in the mouth consciousness of the occlusal relation is derived from sensations transmitted through the teeth, which are sensitive tactile organs and give instant knowledge of the position of the mandible whenever they are in contact. Absence of muscular strain and absence of a strained feeling at the joint also contribute to a knowledge of this occlusal relation, but the muscular apparatus itself does not possess a sufficiently accurate muscle sense to convey this information. If the mandible is not forward of the incisive relation, the inclined planes of the cusps of the teeth form guides, which serve to insure its return to the occlusal position when the elevators are contracted. At the posterior end of the mandible the fossæ present inclined surfaces which serve as guides to the condyles in their return to the distal position occupied by them during occlusion. With the teeth missing we have only the temporo-mandibular joints as guides in directing the mandible back to the occlusal position. A further consideration of this joint will serve to give a clearer understanding of the problem under discussion.

The temporo-mandibular articulation is a condylarthrodial joint. Into the glenoid fossa, which at its posterior extremity presents a marked concavity, fits the condyle of the lower jaw, with the interarticular fibro-cartilage interposed between them. The condyle is attached to the rim of the fossa by means of the capsular ligament, to the center of which latter the cartilage is attached. The ligament thus binds the condyle in its fossa and imposes certain limitations upon its movement. The anterior portion of the fossa presents a flat articular surface over which the condyle and cartilage may glide in the various movements of the mandible. During the protrusive movements of the jaw this arrangement permits the condyle to slide forward upon the floor of the glenoid fossa, in which movement it is accompanied by the cartilage. At any time during this forward movement the mandible may rotate about a horizontal axis, passing through the the condyles as they rest on the cartilages, and a combination of these two movements frequently takes place. These movements may be bilaterally symmetrical or there may be movements of one condyle forward and inward, the other remaining in the distal part of the fossa. When the mandible is depressed the condyles also slide forward in the glenoid fossæ. This is due to several anatomical peculiarities of the joint as well as to the fact that the external pterygoid muscles pull forward both the condyles and cartilages. The external and internal lateral ligaments are attached to the neck of the condyles and extend so far forward in their attachment to the rim of the fossæ that they serve as fulcrums to force the condyle forward during the depression of the mandible.

In returning to the position of occlusion from any of these excursions it is by retraction and elevation or some combination of these movements according to the position from which the return is made. Normally this is accomplished by the contraction of the masseter, temporal, and internal pterygoid muscles, sometimes in combination with the muscles attached to the anterior end of the mandible. By the contraction of the elevators the main body of the jaw is drawn upward and backward when the condyles slide up the inclines of the glenoid fossæ into their most distal parts. The lower fibers of the temporal muscle, the inner fibers of the internal pterygoid, and the posterior fibers of the masseter muscles serve to draw the jaw back, opposing the action of the external pterygoid, though not directly in line with it. For complete retraction to occur there must be total relaxation of the external pterygoids, as these muscles have the power of fixing the condyles at any point in their return path. If the condyles are thus fixed at any point before their most distal position is reached, the elevation of the mandible may continue by rotation about this now fixed axis. When the anterior end of the mandible is completely elevated, it will then be forward of the occlusal relation, when, if the natural teeth are present, their contact serves to give information of the fact. But with the edentulous patient this source of knowledge is removed, and he is unable to assist in the operation of securing the proper occlusal relationship. Even though there is a complete understanding on the part of the patient as to what is required, he no longer possesses the means of judging if this is obtained, and his efforts are not only not helpful, but often greatly hinder the work of the dentist.

After the loss of the teeth, changes in the joint incident to this condition frequently further complicate the problem at hand. The elevator group of muscles, being no longer accommodated to a fixed position of the mandible, usually shorten, as do the other tissues extending between the jaws. The ligaments of the joints become stretched and the articulation becomes loose and wandering. The anterior portion of the glenoid fossa becomes resorbed, resulting in a flattening of its floor, all of which factors tend to make the protrusive movements easy and those of retraction uncertain. The longer the teeth have been absent, the greater will be the tendency toward protrusive movements. Lack of precision in the movement of the jaw will also frequently be increased by the various manipulations incident to fitting the bite-plates.

It becomes very difficult, therefore, to secure the jaw in its distal position. In this operation efforts are directed to compel the patient to close the mouth and bring the bite-plates together, and to have the jaw slide back to its proper position. Measures which are utilized to fix the plates together at the same time that the mouth is closed are open to the criticism that they serve to increase the protrusive tendency if much force has to be exerted in bringing the jaws together, and great care must be taken to avoid this error. It may be stated as a truism that the smaller the amount of force necessary to close the jaws, the less likelihood will there be of protrusion. Goslee[1] has called attention to the tendency to a continuation of the incising relation which may be caused by having too much wax upon the anterior part of the plates. This offers the same sort of resistance to the closure of the jaw as is met with in incising food, and the muscular movements which are useful in incision are reflexly provoked thereby. Instructing the patient "to bite" usually conveys the idea "to incise," that being the common meaning of the word, and the movements of that operation are suggested. It is safest to use the term "close the mouth" in giving directions during the procedure, as that more nearly than any other suggests the desired movement.

The operator must be able to tell when the jaw is in its posterior position, in which he may be assisted by palpation of the external end of the condyle, and by inspection of the surface of the skin during its motions, and by resorting to the measures which induce its backward movement. While it is there, the bite-plates must be marked and so trimmed that their anterior surfaces are flush, to serve during subsequent procedures as an indication as to whether the jaw is protruded. The median line may also to advantage be marked upon both plates so that a protrusion of one condyle would be noted. The plates should fit firmly, be comfortable and stable in position, and the patient should be engaged in conversation, and, if possible, made to forget the operation. Then they should be taken out, wiped dry with a napkin, and replaced, and a small quantity of very soft yellow wax placed over the grooves on each side of the lower plate. The patient is then directed to swallow, and, as the lower jaw has to be fixed for this operation to give a base from which the elevators of the larynx may work, the condyles are usually forced back in the fossæ. By this means the patient is engaged in the performance of an act which is naturally done when the condyles are back in their fossæ and the tendency to protrusion is thereby considerably reduced. It must be observed that the bite-plates have been brought into the proper relation, and also it must be assured that they are in position on the ridges. It may occasionally be necessary to hold them in position, especially in the case of a lower jaw in which there has been much resorption.

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[1] Taking the Bite, Dental Rev., vol., **17**, p. 509.

If the head is thrown backward, the tissues of the front of the neck attached to the lower jaw, particularly the platysma myoides, are put on the stretch, the tendency being also to carry the jaw backward. Instructing the patient during closure of the mouth to touch the palatal vault with the tip of the tongue as far posteriorly as possible, also has the advantage of tending to keep the jaw far back. Asking the patient to bite the back teeth together may assist in securing this position, because of the fact that in the natural denture this is not possible when the jaw is protruded. Efforts to hold the jaw back by clasping the fingers behind the ligamentum nuchæ and pressing with the thumbs on the chin, or pushing it back forcibly by pressure on the chin during the closing, have been recommended and in some cases they may be successful, but frequently they are so resisted by the patient as not to be effective.

In view of the fact that it is the external pterygoid muscles whose contraction prevents the return of the condyles to their most distal position, it is sometimes effective to tire out these muscles by requiring the patient to move the mandible rapidly and energetically alternately as far forward and as far backward as possible, the bite-plates being kept in contact during these excursions, until the patient complains of fatigue, when the relaxation of these muscles allows the mandible to assume its normal rest position in a natural and unstrained manner.

The method of securing the centric relation rest record advocated by Gysi and described on page 193 is a splendid check upon the correct occlusal relation in all cases. In the opinion of many, it is the only absolutely positive means available at present of proving that the mandible has been secured in its correct distal position, and the reader is specially referred to this description which is included in another section because of its relation thereto.

The wax interposed between the two plates should be small in amount and quite soft. It serves two purposes—to unite the bite-plates in the position of occlusion and to compensate for any failure of their occlusal surfaces to be in uniform contact. It is difficult in trimming an unyielding substance like modeling compound to get two surfaces to fit absolutely accurately, although, of course, this should be attempted. The wax at properly distributed points offers enough resistance to hold the plates in contact with the membrane, but not enough to interfere with the accuracy of closure. Care should be taken to see that the labial surfaces of the plates are flush, since by this means it may be seen that the jaw is in its most distal position. The bite-plates may be fixed by fusing their edges together with a hot spatula, or by the use of staples of wire inserted on each side to bind them together, or in very difficult cases in which it is desired to interpose no resistance to the contact of the bite-plates, thin plaster of Paris may be used for the purpose as has been recommended by Ottolengui.[1]

Another method of fixing the bite-plates together is to cut three grooves about $\frac{1}{8}$ inch deep in the occlusal surface of the upper bite-rim. When the occlusal relation is to be taken, the surface of the lower bite-rim is softened by heat to a depth of about $\frac{1}{16}$ inch, it is quickly placed in the mouth and the patient directed to close. Thus some of the softened material is forced into each groove, furnishing an accurate guide for the correct relations of the bite-plates when removed from the mouth, and also a guide in the return of the mandible to the same position during subsequent manipulations in the mouth. Furthermore this likewise serves to adjust the lower bite-rim to an even bearing upon the upper one.

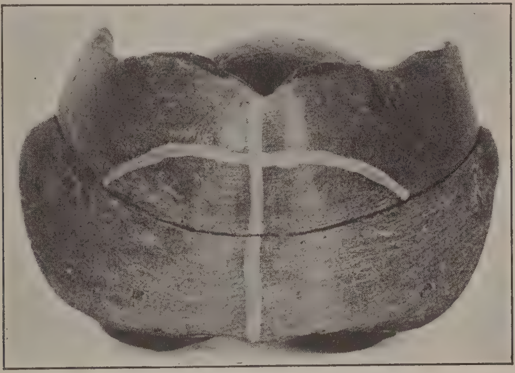

FIG. 104.—Upper and lower bite-plates showing high lip line and median line of the mouth.

The High Lip Line.—In the usual movements of the lips in speaking the teeth are more or less exposed to view, and even greater displayal of the denture is made in laughing and smiling. The relation between the lips and the teeth in laughing and smiling has much to do with the beauty of these acts. It is usual, therefore, to take into account the amount of this exposure in the construction of artificial dentures, and the highest point to which the patient can elevate the upper lip should be indicated by a line drawn upon the upper bite-plate at the lower margin of the upper lip. This lip is more mobile than the lower, because a larger number of muscles move it, and more of the upper teeth are displayed in smiling and laughing. In separating the jaws the lower teeth are depressed below the margin of the lower lip, and it is usual to disregard this record on the lower bite-plate for the additional reason that the upper having been determined, the proportions of the lower are more or less harmonious therewith. It may, however, be marked upon the lower bite-plate and is then "the low lip line."

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[1] Dental Cosmos, vol. **44**, p. 446.

The Median Line of the Mouth.—This should always be recorded, for in a normal natural denture the line between the central incisors practically coincides with the median line of the mouth. The median line of the mouth is more or less difficult to determine for lack of an accurate guide in judging it. The frenum of the upper lip is usually in the median line, but it is by no means a safe landmark, for in a good number of cases it is a little to one side or the other. The median line of the cast and the little tip on the front of an edentulous upper cast, representing the incisive pad of the rugæ, are also unreliable; because the cast is frequently unsymmetrical from the fact that the teeth on one side may have been lost earlier and the resorption taken place to a greater extent than on the other side. The median line of the mouth must, therefore, be secured by data obtained from the face. The tip of the nose is so frequently out of the median line that it should not be used. The philtrum, when not obliterated, is a safe point of reference. The base of the septum of the nose and the median line of the chin may also be used. The mouth itself is sometimes from habit or otherwise one-sided, and then the line fixed upon as the median line should occupy a position between the median line of the mouth and that of the face. After it has been determined upon, it should be marked upon both bite-plates perpendicular to their line of division while they are still in the mouth. Fig. 104 shows the bite-plates removed from the mouth and exhibits the median and high lip lines.

BITES FOR FULL UPPER AND LOWER DENTURES.

The bite for a full upper plate where the lower natural teeth remain in whole or in great part, or where a satisfactory lower denture exists, involves the construction of a bite-plate in accordance with principles already outlined. It should be tried in the mouth, trimmed tentatively for contour and length to the lower margin of the upper lip, and the patient requested to close the lower teeth upon it. Special care should be taken to see that the lower teeth strike evenly upon its occlusal surface, and, when the jaws are closed in the position of occlusion, the lips and cheeks should be lifted so that it may be seen whether this is the case, and an excavator should be used to try to pry the jaws apart at each tooth to prove the contact. The external contour and distance between the jaws should be established in accordance with the principles which underly their determination in full upper and lower cases. It must be remembered, however, that in determining the length of the upper bite-rim, provision must be made for the proposed over-bite. If the length of the upper lip in repose is taken as the guide, on the bite-rim trimmed $\frac{1}{16}$ inch below this, when the teeth have been set up on the articulator and are tried in the mouth, it will be found that they will appear too long because the amount of their over-bite has not been taken into consideration. The length of the upper bite-rim must therefore be adjusted with this fact in view. After the plate has been satisfactorily shaped to fulfil these requirements, it is removed from the mouth, wiped dry with a napkin, and the occlusal surface covered with a thin layer of very soft yellow wax, which should be made to adhere closely, and only thick enough to receive indentations of the occlusal surfaces of the lower teeth. It is replaced and the mouth closed as in the previously described bite-taking operations. The patient should bite into the wax until the cusps of the teeth touch the bite-plate, which insures that the distance between the jaws is the same as was determined by the bite-plate. It is important that only a small amount of wax be used because of the increased tendency to protrusion caused by too great a quantity. The bite-plate may be marked with a line to note the position between the lower central incisors to assist in bringing the lower jaw to a correct position, and the relation of the incisors to the edge of the bite-plate will also assist in this purpose.

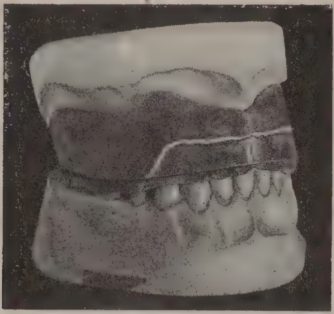

FIG. 105.—Bite-plate for full upper denture in case in which the lower natural teeth remain. Cast set in bite-plate preparatory to mounting in articulator.

The high lip line and median line of the mouth should be marked upon the bite-plate, since the line between the lower central incisors is too frequently out of center to be depended upon for setting up the teeth, and the median line of the mouth is a safer guide. The bite-plate should be removed from the mouth, the wax chilled in water and laid aside, and an impression taken of the lower jaw, a cast made and fitted into the depressions in the wax of the bite-plate (Fig. 105).

Bites for Full Lower Dentures.—In taking the bite for a full lower denture, a bite-plate must be made for the lower jaw as described earlier in this chapter. It rarely occurs that the upper natural teeth remain in a mouth in which all the lower have been lost, and the common case requiring a full lower denture is that in which there is already a satisfactory upper. The general procedure is the same with either artificial or natural upper teeth. The lower bite-plate is formed and trimmed to occlude evenly with the upper teeth, and of such length that the distance between the jaws as determined by the appearance of the patient is correct. The bite-plate is given a layer of wax over its occlusal surface and the bite taken in the usual way. Where there is an artificial denture for the upper jaw, it is well to remove this with the bite, to mount it upon the articulator, and to articulate the lower teeth to it rather than to a cast formed from the tooth depressions in the wax. Where the denture has been made some time before the lower teeth were lost, and particularly where the teeth are set at irregular levels to occlude with the natural ones, it is advisable to reset them with the lower teeth, as a much more satisfactory occlusion may be obtained.

Bite-plates for Temporary Dentures.—These differ in no wise from the plates already described, except that they do not extend over the labial surface of the cast, this being more especially true of those for the upper jaw. This arrangement is, of course, necessitated by considerations of contour. They are, in consequence, more difficult of retention, and this must be looked for and provided for by means already discussed.

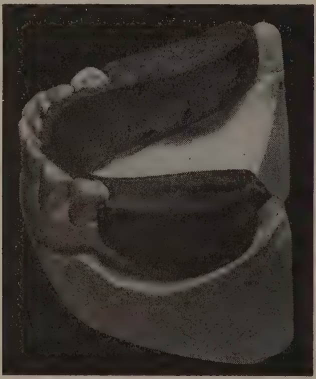

Fig. 106.—Bite-plate for partial lower denture

Bite-plates for Partial Dentures.—Except in those cases in which only a few teeth have been lost, bite-plates must be constructed for taking the bite for partial dentures. In general it is better to construct them of a thin sheet of modeling compound rolled out to about the thickness of No. 12 gauge, adapted to the cast, and trimmed to the plate outline. Vacancies between the teeth are built up with additions of modeling compound to the level of the adjacent teeth at such places as it is necessary that the plate should oppose a tooth in the opposite jaw and stay the bite (Figs. 106 and 107). Where the natural teeth remaining occlude and stop the closure at that point, these spaces on the partial bite-plate may be built up with soft wax just before the closure for fixing the bite is made, the soft wax receiving an impression of the opposite teeth.

Partial bite-plates may often be strengthened to advantage by imbedding iron or brass wire of proper shape in them at such places as will be exposed to strain, and this is particularly true of partial lower plates.

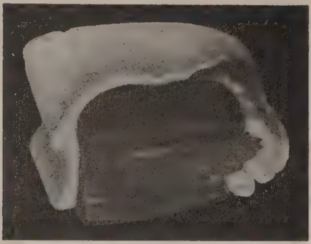

Fig. 107.—Bite-plate for partial upper denture.

Taking the Bite in Partial Cases.—1. In the construction of dentures for partial cases where the remaining natural teeth occlude properly and particularly if only a few have been lost, it is only necessary to be assured that the teeth of the casts occlude in the same way that the natural teeth do, and, if there are enough points of bearing, occasionally they may be mounted on the articulator without taking the bite. If, however, a roll of soft yellow wax is placed between the patient's teeth and they are brought to the position of natural occlusion, the wax may be pressed up with the fingers, cooled with water, removed from the mouth, and the casts may be fitted into the wax with the assurance that their relation is correct. Two sheets of red base-plate wax with a sheet of heavy tin-foil (about No. 60) interposed are useful in securing an accurate record of the relationships of the natural teeth. When this is warmed, placed in the patient's mouth, and the latter instructed to close, the pressure of the teeth will swage the tin-foil into the sulci of the teeth, thus giving a stiffer and more reliable means for the correct mounting of the casts in the articulator. It is important to be certain that the teeth come into the position of correct occlusion when the jaws are closed upon the wax, and it is expedient to mark opposite points with a lead pencil upon the external surfaces of two teeth that occlude, and to observe if these bear the same relation when the jaws are closed for the bite. This includes partial upper or partial lower dentures or both.

2. Where the teeth remaining do not occlude, as in the case of a partial upper and partial lower denture, it is, of course, necessary to have bite-plates to establish the distance between the jaws, as was done with the full upper and lower. These are trimmed tentatively to correspond

in the length of their occluding portions with the adjacent teeth and are tried in the mouth. The same general principles which determine the length of the full upper and lower bite-plates must be borne in mind, but the length of the remaining natural teeth will be the main guide in determining the trimming. The plates and teeth should occlude with the same evenness and firmness which is demanded of the full plates, each tooth striking upon the bite-plate. The plates are removed, wiped dry, and their occlusal surfaces covered with softened wax, and the bite taken as has been before described. With a full denture for one jaw and partial for the other, as in a case in which some of the lower natural teeth remain, the obvious method is to combine the principles of bite-taking for partial and for full dentures, being guided by the natural teeth as to the length of the bite-plate, by the external appearance of the patient as to the contour and the distance between the jaws.

3. There are occasional cases requiring partial upper or lower dentures or both where the remaining natural teeth occlude, but where they are either much abraded or have been driven out of their places by the force of occlusion, and the distance between the jaws which they establish is insufficient. It is usually advisable in such instances to "open the bite." The bite-plates are trimmed to a length in accordance with the amount it has been determined the jaws are to be separated, and the procedure is the same as where there were no points of occlusion. It must be borne in mind that the natural teeth separated by this measure should be built up by operative measures or by crowning, if possible, as they cannot otherwise participate in the masticatory functions of the denture. Instances demanding this procedure are not of frequent occurrence, but a few cases are much simplified and the mouths much improved by thus establishing a new position of occlusion.

The determination of the relation of the jaws to the temporo-maxillary articulations, and the determination of the path of the condyle in its forward and lateral excursions are questions so closely related to the subject of articulators that it will be necessary to consider them conjointly.

ARTICULATORS.

Introductory and Historical.—The invention of the instrument known as the articulator is attributed by Guerini[1] to J. B. Gariot about the year 1805. As originally designed, it was merely intended as a convenient means of maintaining the plaster casts in their correct occlusal relationship during the operation of arranging the artificial teeth. In its earliest form it consisted of two metal frames to which the casts could be attached, joined by means of a simple hinge mechanism, and provided with a set screw or stop to hold the frames a fixed distance apart. The casts were mounted upon the frames in accordance with the record taken of the proposed occlusal relations of the jaws. The hinge permitted the separation of the casts during the various manipulations of setting the teeth, while the stop ensured the return of the casts to the correct occlusal relationship when desired. Many forms of this simple instrument have been employed since that time, and it persists today in the so-called "plain line articulator." As the hinge of the device is not intended to represent the temporo-mandibular joint, nor to imitate its movements in any way, the utility of the device is limited to establishing or maintaining the occlusal relationships of the artificial teeth, and it is of no service in setting the teeth in accord with methods of articulation employed at the present time through which their functional efficiency is greatly enhanced.

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[1] The Dental Cosmos, vol. **43**, p. 8.

While an articulator with a slot arrangement permitting a sliding motion at its joint was patented by Evans[1] in 1840, it is probable that the first instrument embodying the idea of a mechanism which would reproduce the mandibular movements of the patient, was that designed by W. G. A. Bonwill, said to have been developed in 1858, and demonstrated before the American Dental Association in 1864.[2] (Fig. 108.) With this apparatus, a serious effort was made to imitate the movements of the mandible in its forward and lateral excursions. The joint mechanism consists of a ring sliding upon a round bar, in imitation of the sliding movement of the condyle, the direction of the bar determining the path of the ring. The latter is attached to the portion of the instrument carrying the upper case, the bar being a part of that carrying the lower cast. So long as the upper and lower bows of the device are parallel, the path of the mechanical condyle is parallel to them and hence in a horizontal plane. When the lower bow is depressed in imitation of the opening movement of the mandible, the bar is correspondingly elevated, its angle with the horizontal plane is changed, and the path of the condyle is represented as descending in an amount proportional to the degree to which the lower bow has been depressed. This is a faulty principle, as it is obvious that an instrument in which the portion representing the condyle path as changing its direction during the opening movement does not reproduce the conditions found in the human mechanism.

The instrument represents the centers of the condyles as 4 inches apart, and it is directed that the casts be placed upon the articulator with their general alveolar planes parallel to the loops to which they are attached, the central point of the lower bite-rim being located 4 inches from each mechanical condyle center. This is based upon Bonwill's familiar theory of the equilateral triangle as representing the typal design of the lower jaw, which presupposes a uniform intercondylar distance of 4 inches and a like distance from each condyle to the center of the lower denture. It is a well known fact that all mandibles do not conform to these measurements, and that a considerable variation from these specifications commonly exists. The instrument is the embodiment of an idealized concept which is not in accord with actual anatomical conditions.

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[1] Wilson: Dental Prosthetics, 1920, p. 177.

[2] Am. Dent. Assn. Trans., 1864, p. 76.

Bonwill's ideas were accepted by a limited few, and two decades passed before any appreciable interest was displayed in articulator design. W. E. Walker[1] made a serious study of the problem and in 1897, developed an articulator with individually adjustable condyle paths and other improved features together with measuring instruments by which the condyle registrations could be set for the case in hand. The apparatus was too complicated to make any general appeal at the time and it never came into wide use. (Fig. 109.)

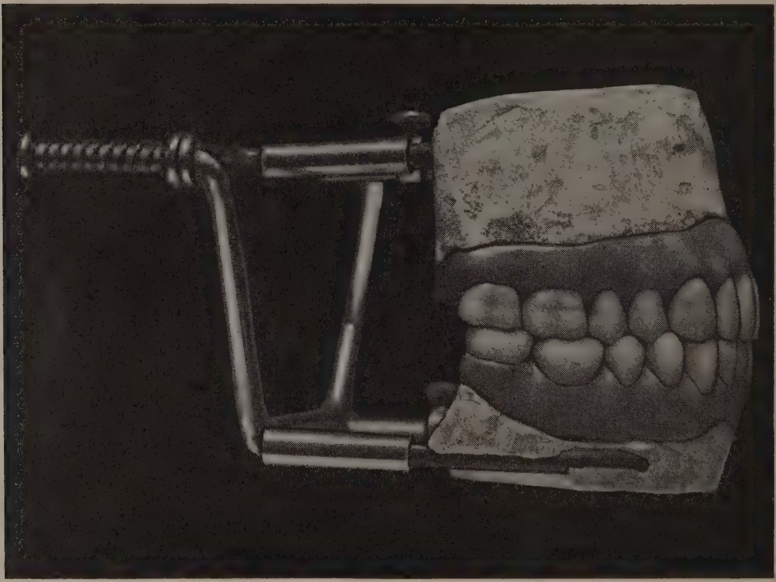

FIG. 108.—Bonwill articulator. (Photograph of intrument in collection of the Department of Dentistry, University of Pennsylvania.)

Since 1900 interest in this question has gradually become widespread, and there have been a large number of contributions to the study of articulators and their related problems. Almost innumerable devices have been designed, embodying a great variety of ideas. The purpose in the mind of each designer has been the production of an instrument capable of imitating those movements of the mandible which are directly concerned with the articulating relations of the teeth, in accordance with the designer's idea of the nature of these movements and of their relative importance. The inherent difficulty of studying the motions of the mandible in the living subject and of securing accurate registration records of these movements, has been the fundamental obstacle in the work upon this problem. In direct proportion as the knowledge of the exact character and the significance of mandibular movements has been extended, has truly scientific progress been made in articulator design.

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[1] The Dental Cosmos, vol. **39**, p. 789.

The limitations of this text obviously preclude a detailed discussion of the various instruments that have been presented to the profession during the last twenty-five years, nor would it be useful in the present connection. Dental periodical literature, as well as many books and pamphlets published during this period, contain full descriptions of these devices and the principles underlying their use. While many of these published articles strongly suggest the enthusiastic partisanship of their authors they include numerous substantial contributions of a truly scientific character. It is not the purpose of the writers to present a controversial discussion of this subject, but it is essential that a clear definition be made between contributions based upon established and demonstrable scientific fact, and those not so supported. It is but natural that in the development of any phase of scientific thought, truth and error should frequently be found closely associated. The complexity of this subject and its inherent difficulties have rendered a discrimination between the true and the false almost impossible except for the few who have subjected it to the most exacting scrutiny.

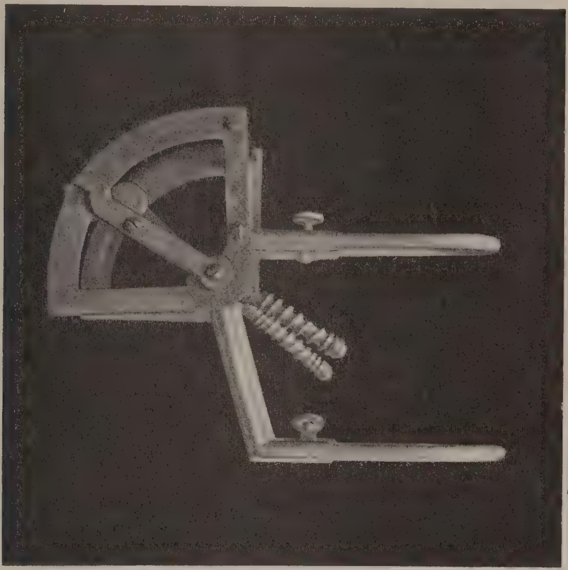

Fig. 109.—Walker's articulator.

The conclusions herein presented and the methods advocated represent the best contemporary thought in this field.

The Function of the Articulator.—The employment of a so-called "anatomical" articulator is to establish such correlation of the forms of the occlusal surfaces and relative positions of the teeth of artificial dentures with the movements of the mandible characteristic of the patient for whom the dentures are intended, as will give them the maximum of efficiency and stability. Once the casts have been properly mounted, and the instrument adjusted, this assembly furnishes a reproduction of the dental mechanism of the patient upon which the artificial teeth may be arranged to meet the above requirements. The articulator should be capable of limitation to fixed paths of motion in exact imitation of any movements of the patient's mandible which can occur when the teeth are in contact, and should exclude all other movements during such contact. The principles underlying the selection of suitable teeth and their arrangement to meet the desired ends are discussed in later chapters.

Articulator Design.—The design of several articulators has been based upon some purely theoretical or preconceived conception of the kinematics of the dental mechanism. For example, that of Rupert E. Hall which appeared in 1914, is based upon the idea that the movement of the lower teeth over the surfaces of the upper in mandibular excursions, is their movement over the surface of a cone with a generating angle of 45 degrees, the axis of the cone being in the median sagittal plane at an angle of 45 degrees with the horizontal plane, and its apex somewhere near the occipital protuberance. The axis of the opening movement is not at the level of the condyles but in the same horizontal plane as the plane of occlusion. This was later improved mechanically by M. M. House as the Hall-House Precision Articulator but its general principle remained unaltered. (Fig. 110.) The designer maintained that contacts of the cusps of the teeth during mandibular movements determined the nature of the latter, and that the temporomandibular joints had no influence on the character of these movements and would adjust themselves if necessary to the movements which the tooth cusps permitted. As many dentures articulated on this instrument did not articulate in the mouth, a wholly new system of balancing contacts was devised embodying two contacts between the dentures, a third being provided by the food between the teeth on the working side. That the principle upon which this instrument is based is erroneous and not in accord with anatomical fact has resulted in its being relegated to disuse by its former advocates.

Another instrument which is now in contemporary use is that devised by George S. Monson presented in 1918 and called a "Maxillomandibular Instrument." (Fig. 111.) It is based upon the conception that the lower teeth move over the surfaces of the upper as over the external surface of a sphere with a radius of 4 inches, the surfaces of the glenoid fossæ over which the condyles glide being surfaces of this same sphere or one concentric therewith, the center of the sphere being in the sagittal plane and located in the general neighborhood of the glabella.

This is derived from the idea evolved by von Spee, which has been elaborated by various workers since his time, notably by Villain.[1] While this concept of the typal mechanical design of the dental mechanism serves admirably as a means of portraying in graphic terms the movement of the mandible in relation to the maxillæ, it should only be regarded as such, and it cannot be successfully incorporated in articulator design. While the Monson articulator may provide the means of approximately reproducing the movement of the mandible in its forward excursion, it is not in accord with the widely accepted conclusions about the guidance afforded by the mandibular condyles in the lateral movement of the mandible. In this device lateral movement takes place about a single central axis placed at an angle of about 45 degrees with the general plane of occlusion of the teeth, whereas

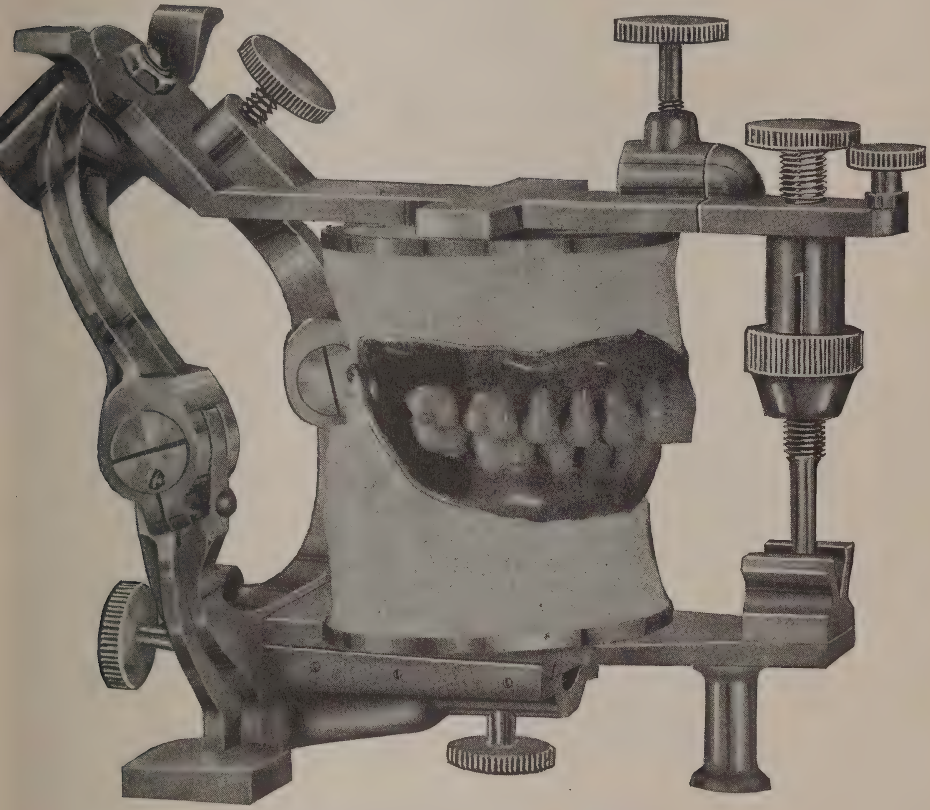

Fig. 110.—Hall-House Precision Articulator.

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[1] Prothèse: Principes Generaux, p. 97 *et seq.*

the mandible itself does not rotate about a central axis in its lateral excursions.

Other articulators that have been presented for acceptance by the profession may be grouped into three classes. In all of these the importance of condylar guidance in the movements of the mandible has been recognized. A first group consists of those in which certain portions have been made adjustable to meet the indications of a given case, but are not completely adjustable in regard to each of the several factors influencing the movement relations of the mandible. In some of these the influence of certain variables is not recognized at all, while in others they are regarded either as negligible or as satisfied by an average registration. Another group consists of those in which the average of each of the various variable elements is permanently fixed in the articulator structure upon the theory that an average will be suitable for a large number of cases, and that exceptional cases may have their error corrected by adjustment in the patient's mouth.

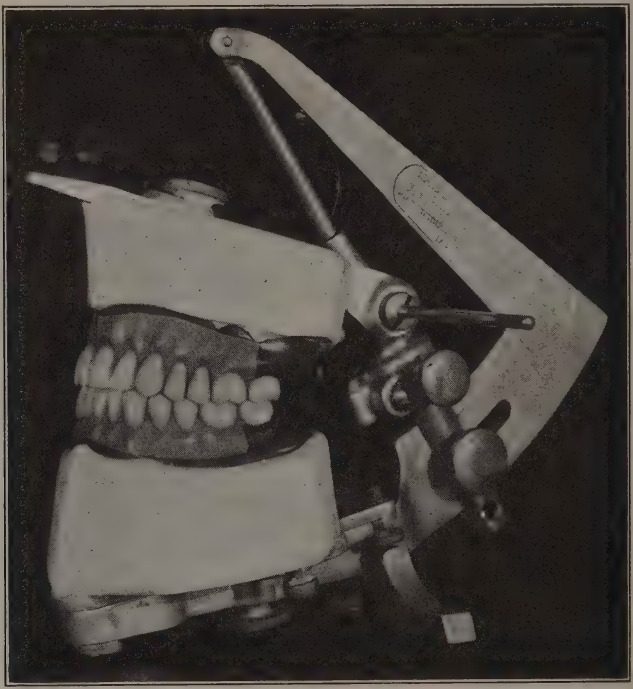

Fig. 111.—Monson articulator.

The third class includes those in which an effort is made to provide an adjustable mechanism to represent each variable influence on jaw movement, in order that the instrument may be completely adapted to the indications of each individual case.

According to the best thought of the present time, an articulator to be completely adaptable to the requirements of the individual case must include provision for adjustment in the following particulars:

Individually adjustable condyle paths.
Individually adjustable rotation centers.
Reproduction of individual lateral movement of mandible.
Changeable inclined plane for incisal guidance.
Means for the correct location of casts with respect to the joint mechanism.

It may well be asked why many articulators have enjoyed such wide use when their architectural plans have been so much at variance, and whether it has been possible to employ them with any degree of satisfaction. That many of them have given satisfactory results in a certain number of cases, there can be no question. This is due to several facts, some of which are independent of the design of the instrument. That some of the more scientifically designed give poor results in the hands of certain users is attributable partly to unskilled usage, and partly to the inherent difficulty of securing accurate measurements for registration upon the instrument. Stretching of the joint ligament and the resilience of the base upon which the dentures rest often compensate for errors of construction. Articulators with fixed average registrations certainly give satisfaction in a limited number of cases. Grinding the surfaces of the teeth, and milling them in the patient's mouth by the use of an abrasive, serve to correct many errors of articulation, while improved methods of retention often render dentures satisfactory to the patient when they fall far short of mechanical excellence. Some of the variants have more influence on the relations of the teeth during mandibular movements than have others, and as these variants have a definite reciprocal relation, an error in one may be compensated by an error in another. Nevertheless, each one of the variable factors above mentioned plays some part in mandibular movements, and no articulator can be considered wholly satisfactory in which any of these is neglected.

Adaptable Articulators.—The Gysi Adaptable Articulator,[1] appearing about 1910, included provision for all the variants known at that time, and in addition, the use of the incisal guide rod and inclined plane upon which it moved, the latter being one of the most important additions which has been made in articulator construction. Prior to this time, the artificial incisors attached with wax to their base-plates, have served to guide the front end of the instrument in its forward and lateral movements. Because of their uncertain effect in this relation especially in warm weather, the gliding of the incisal rod upon its inclined plane more effectively imitates the effect of the incisor over-bite in causing an opening movement during the forward excursion, and prevents the downward movement of the upper articulator bow in lateral excursions.

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[1] The Dental Cosmos, vol. **52**, p. 148.

This instrument had adjustable condyle paths and rotation centers, together with a complete set of measuring instruments for securing registrations of individual cases. A later model incorporated an adjustment to reproduce the lateral bodily movement of the mandible to which attention was called by Norman G. Bennett. The most recent model (1926) called the "Gysi Trubyte Articulator," possesses a changeable inclined plane for the incisal rod, and more accurate means of reproducing both the rotation centers in lateral movements and the so-called Bennett movement, as well as individually changeable condyle paths. (Fig. 112.)

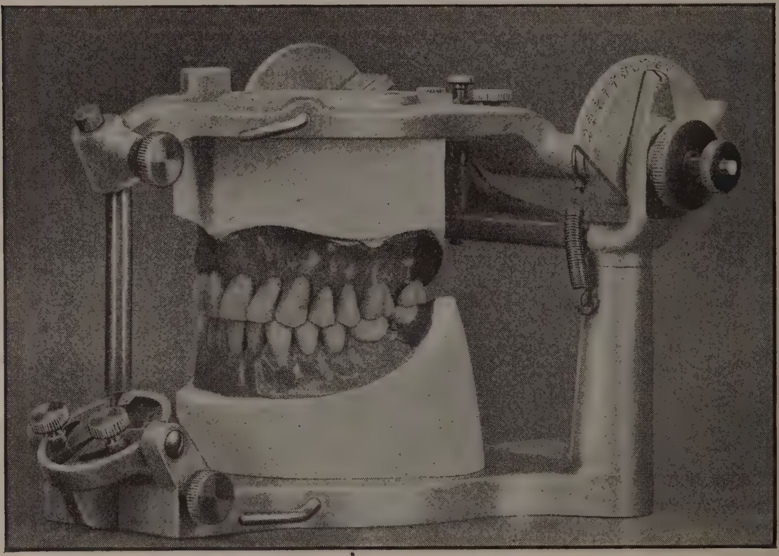

Fig. 112.—Gysi Trubyte Articulator.

In 1921, Rudolph L. Hanau presented his articulator (Model H) and the technic of securing and recording the various registrations provided for in the instrument. (Fig. 113.) This may be regarded as a partially adaptable device as it has provision for adjusting it to many of the variants influencing mandibular movement. As the designer has associated with it his own technic in securing or determining the records in accord with which the instrument should be set, at the appropriate place in the text, this technic will be discussed.

Frederick W. Frahm,[1] W. C. Dolbey[2] and Ichigoro Nakahara (Tokyo) have each devised adjustable articulators, but as these have not been widely used, it appears unnecessary to include their description.

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[1] The Dental Cosmos, vol. **56**, p. 533.

[2] Ibid., vol. **56**, p. 943.

About 1924, the articulator designed by Frank Wadsworth was introduced in its present form. It possesses individually changeable condyle paths, condyle standards which may be set to reproduce the estimated intercondylar distance of the case in hand, two adjustable lateral plates upon which the incisal rod moves in the lateral excursion, and, as a distinctive feature, a superposed "centering plate" for use in scribing the curved plane of occlusion in accordance with the designer's technic which is described in a succeeding chapter (Chapter VII). In the straight protrusive movement of the instrument, the incisal rod glides horizontally in the groove formed by the two lateral guiding plates and thus the effect of the incisor over-bite is not imitated. The technic of articulation advised with this instrument includes the placement of the distal teeth first, and the opening movement caused by the inclined planes of the cusps of these teeth as they glide upon each other when the lower bow is moved forward, produce the effect of

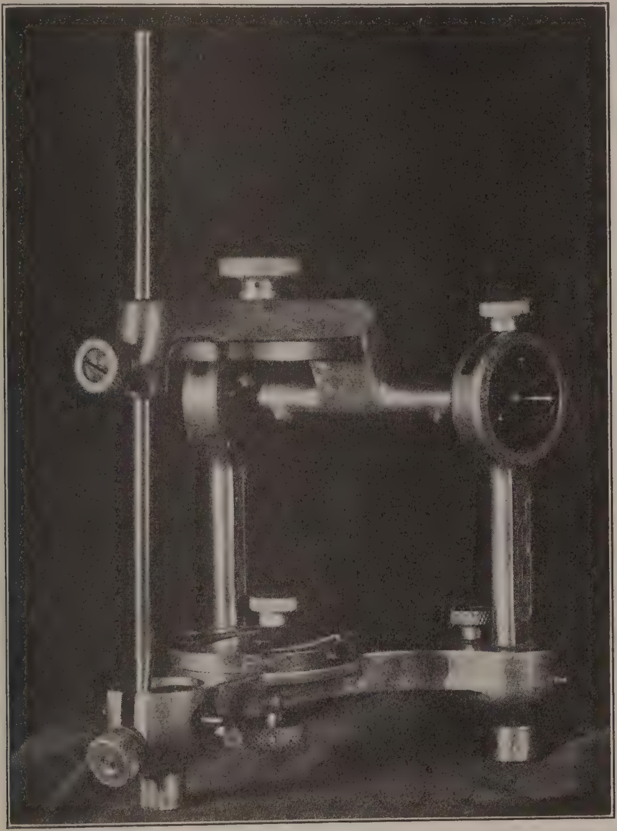

Fig. 113.—Hanau model H articulator.

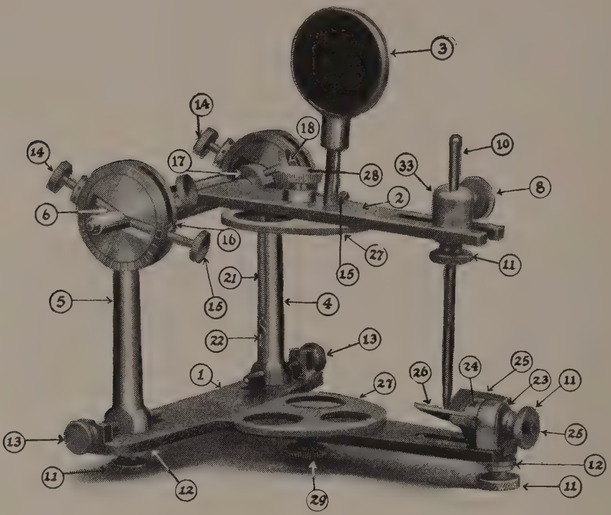

FIG. 114.—The Wadsworth universal articulator; 1, base or lower bow; 2, upper bow; 3, centering plate; 4, 5, condyle standards; 13–13, condyle standard adjusting screws; 6–6, condyle paths; 14–14, condyle path adjusting set-screws; 16–16, condyle rest position screws; 15–15, condyle center adjusting screw; 21–21, condyle tension springs; 27–27, model plates; 28, 29, model plate set-screws; 17–17, condylar distance collars; 18–18, condylar distance collar set-screws; 8, 10, 11, 33, incisal pin unit; 11, 12, 23, 24, 25, 26, incisal grade unit; 11, lock-nut.

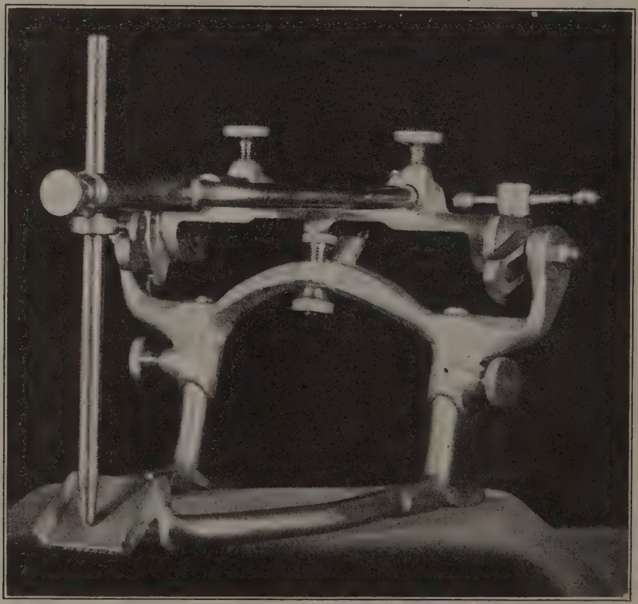

FIG. 115.—Acme articulator.

the over-bite. In this articulator is embodied the idea that the centers of rotation in lateral movements are located in the condyle centers, and the movable condyle standards are to be set to the measured intercondylar distance in accordance with a technic described on a later page.

The Acme articulator, which is an elaboration of one originally designed by George B. Snow, includes adjustable condyle paths, a changeable incisal rod guide, and comes in three models of different widths to accommodate three ranges of intercondylar distance. The so-called Bennett movement is provided for, but in the instrument this is not limited or capable of limitation to the indications of a given case.

Limitations of Articulators.—The anatomical articulator must not be viewed as an instrument of mathematical precision in the sense that it can accurately reproduce mandibular movements and the contact relations of teeth in function. No mechanical device is capable of imitating in its construction the compressibility of the soft tissues intervening between the bones at the temporo-mandibular joint, nor the effect of the elasticity of the ligaments which restrict the jaw movements. Neither can it represent the varying pull of the muscles nor the balance which their varying contraction may establish in jaw relations. Furthermore, it must be remembered that in the mouth dentures rest upon resilient bases which yield under the pressure of mastication, while in the articulator, these dentures in process of construction rest upon unyielding casts of plaster or artificial stone.

These items introduce factors of error which have modified the methods employed in obtaining the registrations in accordance with which the articulator is adjusted for the individual case. The splendid measuring instruments devised by Alfred Gysi were employed to record mandibular movements and jaw relations when the mandible was not in actual function, and hence these records did not represent the actual operating conditions when the dentures were inserted. Their use has been superseded by methods of recording jaw relationships in protruded and lateral bites through the use of plastic materials interposed between the bite-plates themselves in the mouth and subject to pressure between the jaws. From these records the articulator may be set to reproduce not so much the actual jaw movements, but the relations brought about between the jaws as a resultant of these movements. By this method it is believed that the factor of error represented in the resilient denture base is also largely eliminated. Any completely adaptable instrument is suitable for use in this manner.

From what has been said above it must not be inferred that the articulator itself need not be constructed with mechanical precision. Quite on the contrary, it should be staunchly made, entirely free from lost motion, and provided with reliable means for mechanically controlling and guiding its movements once they have been determined and set for the individual case.

It must still be remembered, however, that while this device is an indispensable aid in the articulation of artificial teeth, the final place of trial of dentures is in the mouth. After the teeth have been set upon the instrument, they must be tried in the mouth before being permanently affixed to their base-plate and any errors detectable at this time corrected. Again after they have been finished and milled to satisfactory gliding contacts in the articulator, they may still require further milling in the mouth if the operator has set as his goal that perfection of mechanical adjustment that insures the comfortable and efficient use of the dentures.

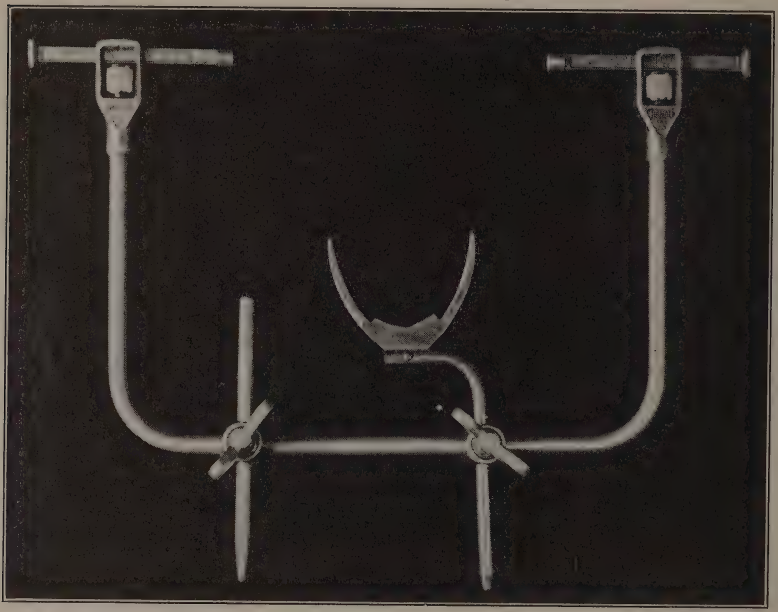

Fig. 116.—Hanau face-bow.

THE RELATION OF THE JAWS TO THE TEMPORO-MANDIBULAR ARTICULATION.

It must be evident that in using an articulator in which the mandibular movements are to be imitated, the casts must occupy the same position relative to the joint mechanism as the jaws occupy relative to the temporo-mandibular joint. Otherwise the joint mechanism would permit the casts to be moved relatively to each other in ways in which the jaws cannot be. A means of determining this with satisfactory precision is furnished in the Snow face-bow or the Hanau face-bow illustrated in Fig. 116, which consists of a stem with a semicircular plate attached for imbedding in the bite-plate, and a bow with a clamping device and projecting index rods at each end of the bow.

The Hanau bow is provided with a semicircular plate with an offset stem which enables it to be used with articulators bearing incisal guide rods without interfering with the latter in setting the casts. The condyle shafts are nicely calibrated, which confers an advantage in accurately adjusting them to the face.

The method of use of the appliance is as follows: After the bite has been taken and the bite-plates are firmly fixed together with the jaws in the occlusal relation, the plates are removed from the mouth, and the casts placed in them to prevent a distortion of their shape in subsequent manipulations. Then the semicircular plate of the stem is heated sufficiently to allow it to be imbedded in the upper bite-plate (Fig. 117), the stem occupying the median plane of the plate, or to one side, if the Hanan offset stem is used. Care should be taken to see that the high lip line, the median line, and the lower edge of the bite-plate, which are to serve for reference in setting the teeth, are not disturbed by this procedure, and also that the plates themselves are not distorted in form or relation. The position of the external end of each condyle while the mandible is in its most distal position is then located by palpation and marked upon the skin of the face by a small piece of court plaster or a pencil mark (Fig. 118). It will be seen in Fig. 48, page 66, that the external end of the condyle is $\frac{1}{2}$ inch anterior to the external auditory meatus and on a line drawn from the bottom of the meatus to the corner of the eye. In many patients the end of the condyle may be easily felt through the tissues covering it; in others by placing the index finger just inside the external auditory meatus, the thumb on the surface of the face just anterior to the position of the condyle, then, requesting the patient to open and close the mouth, the location is determined.

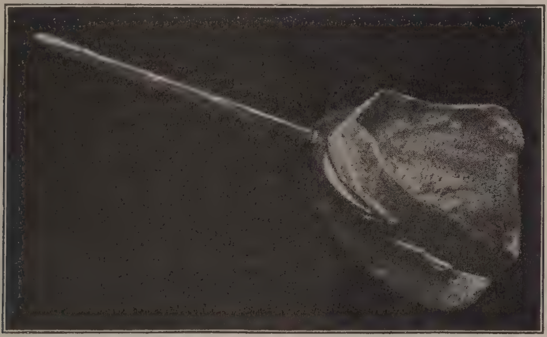

FIG. 117.—Stem with semicircular plate imbedded in upper bite-plate; ready to be returned to patient's mouth.

The bite-plates are then returned to the mouth with the stem, which is now attached to them, projecting between the lips. The bow is put in place, with the stem entering the movable clamp which slides upon the bow, and with the two projecting end pieces or condyle shafts of the bow accurately placed over the condyles as indicated by the pieces of court-plaster on the skin. It is necessary to see that the two project in equal amounts from the bow before the milled clamps which

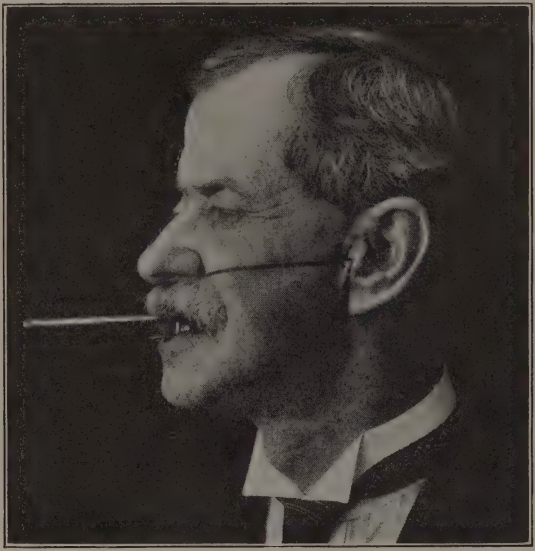

FIG. 118.—Bite-plate in the mouth with stem protruding.

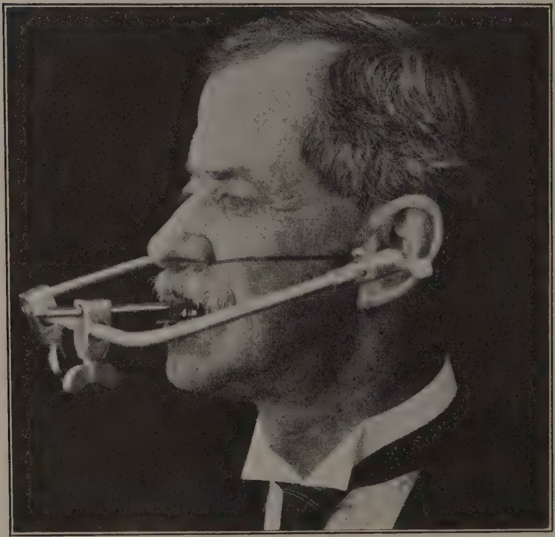

FIG. 119.—Bite-plate in the mouth with face-bow adjusted.

fix them are tightened, because, when the casts are to be mounted on the articulator, and these end pieces are pushed into the external ends of the joint mechanism of the articulator, they must likewise project equal amounts on the two sides in order to assure a centering of the casts. If this were not done, that is, if the two end pieces project unequal amounts when the bow is in position on the face, the casts will not be centered when they are transferred to the articulator. When this has been done, the movable clamp, which fixes the stem to the bow, is tightened, care being taken that the patient's jaws are firmly closed in the bite-plates, and that the end pieces have not moved from their positions over the condyles. (Fig. 119.) The bow, stem and bite-plates, now firmly fixed together, are removed.

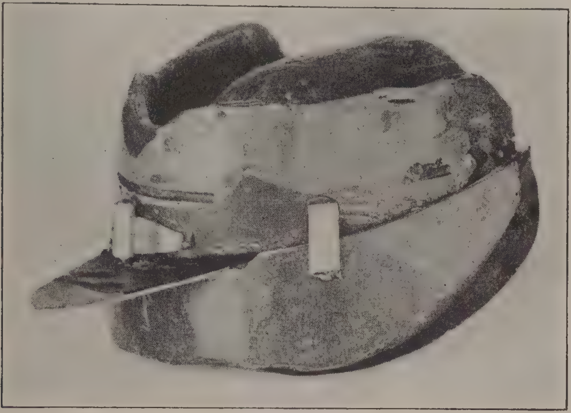

FIG. 120.—Bite-plates united with clamps.

In using the Gysi Trubyte, Hanau (Model H), Acme or other articulator adapted to the use of the face-bow, the instrument is placed upon a level surface preparatory to adjusting and locating the casts. The condyle shafts are pushed inward in equal amounts (this is very important) until they just fit the studs on the articulator provided for their reception. The face-bow is then adjusted in such relation to the upper bow of the articulator that the center of the front edge of the bite-rim is on a level with the pin (provided for this purpose with the instrument) which has been pushed through the hole in the incisal guide rod of the Gysi articulator, or on a level with a groove made for this purpose in the incisal guide pin of the Hanau instrument. The Hanau face-bow provides an upright pin and clamp for holding the bow in this position (Fig. 121). The upper cast may now be placed in position in its bite-plate and attached to the articulator with plaster. When this has hardened, the face-bow may be detached from the stem of the semicircular plate, the articulator turned upside down, the lower cast put in its bite-plate and attached by plaster to the lower bow or plate of the articulator. (Figs. 122 and 123.) This technic may be varied in accordance with a method described later. These measures

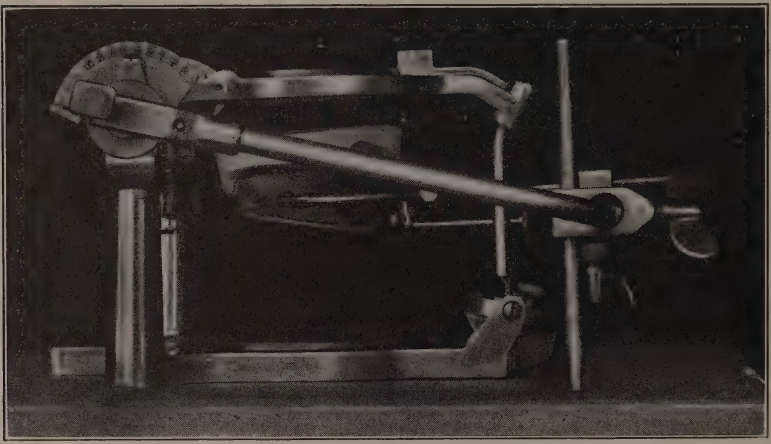

Fig. 121.—Upper cast adjusted to articulator.

not only result in placing the casts in correct relation with the joint mechanisms of the instrument, but suitably orient them and the occlusal plane of the bite-plates between the bows of the articulator.

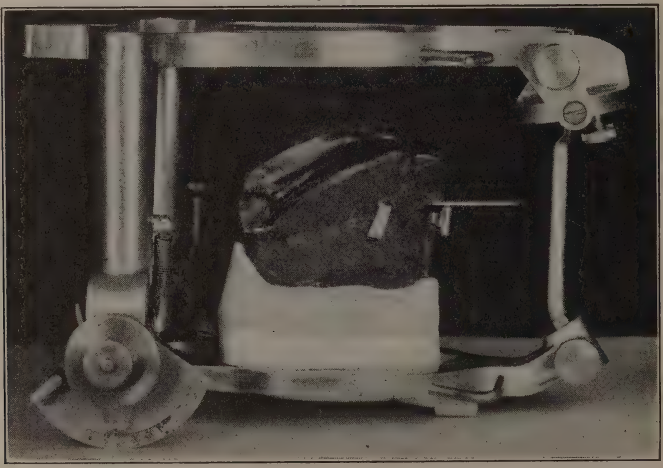

Fig. 122.—Upper cast mounted.

A slightly different technic is employed with the Wadsworth instrument, which, it will be remembered, provides for an adjustment of the intercondylar distance to the indications of the case in hand. Also a different means is employed in orienting the plane of the bite-plates and casts. After the face-bow has been adjusted to the face as described in a preceding paragraph, a "T" attachment is arranged as shown in Fig. 124, with its horizontal portion bisecting the triangle whose

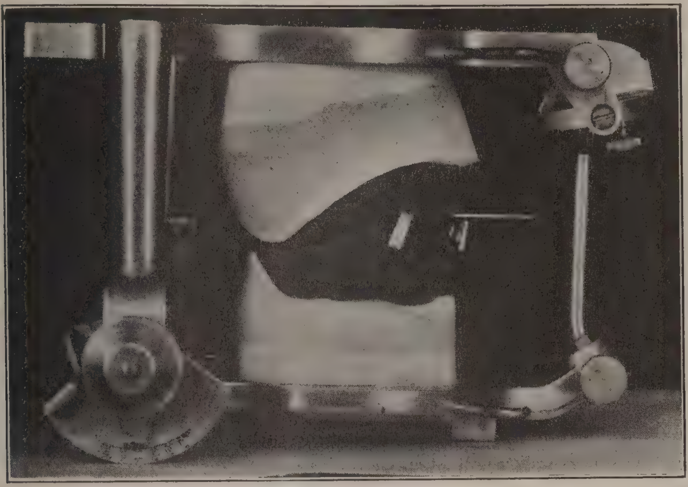

FIG. 123.—Both casts mounted.

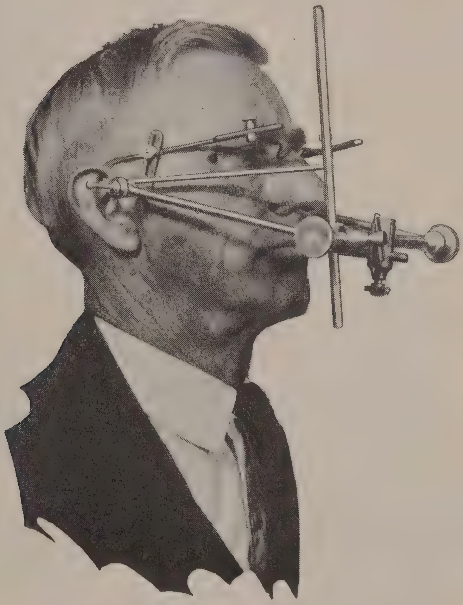

FIG. 124.—The Wadsworth "T" attachment.

angles are located at the corner of the eye, the nasal fossa and the condyle head respectively, and attached to the bow by a clamp. The

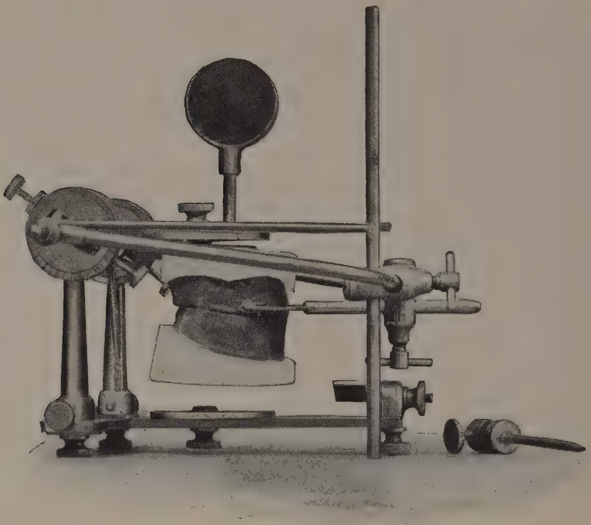

Fig. 125.—Accurate positioning of casts on Wadsworth Articulator.

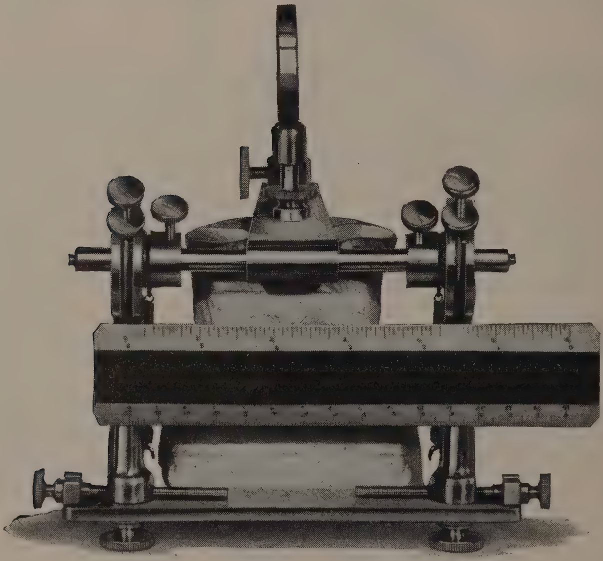

Fig. 126.—Adjusting articulator in relation to face bow records.

vertical portion of the "T" attachment then assumes a position parallel to the facial line. When transferring this to the articulator, the end of the "T" attachment rests on the table, supporting the casts in what

Wadsworth believed to be a close approximation of their correct orientation with respect to the articulator. (Fig. 125.)

To determine the intercondylar distance and record it upon the Wadsworth articulator, when the face-bow is removed the inside distance between the condyle shafts is measured with a ruler. Allowing for a thickness of $\frac{1}{2}$ inch for the tissues intervening between the skin surface with which each shaft was in contact and the center of the corresponding condyle, the true intercondylar distance is obtained by subtracting the allowance for each side or a total of 1 inch from the measurement obtained with the ruler, and the articulator condyle standards are adjusted in accordance therewith.

SECURING RECORDS OF MANDIBULAR MOVEMENTS OR THEIR EQUIVALENTS IN JAW RELATIONS.

Since the most important function of the articulator is to reproduce the mandibular movements or their equivalents of the patient for whom artificial dentures are being constructed, it now becomes necessary to secure the records which will enable the operator to make the correct adjustment of his instrument. As it is only those movements which the mandible can make while the teeth are in contact which have anything to do with articulation, and all others are of no interest or concern to the prosthetist, the records to be secured are few. It is only the paths of the mandibular condyles in the protrusive and lateral excursions of the lower jaw, the centers of rotation in lateral movements, and the extent and character of the lateral bodily movement of the mandible which are important in this connection.

For some time it was believed that graphic records, made upon suitable recording surfaces by the use of measuring instruments actuated by the movement of the lower jaw, furnished the most satisfactory means for the setting of the condyle paths of the articulator, but, as previously stated, their use has been superseded by a method in which records of the various relationships of the jaws are secured through the medium of the bite-plates in accordance with which the condyle paths of the articulator are adjusted. The principle involved in this method, which was first proposed by Christensen[1] in securing a record of the equivalent of the downward and forward paths of the condyles, is explained in the following paragraphs. (Fig. 127.)

Downward and Forward Condylar Paths.—In the forward movement of the mandible of an individual with natural teeth during which the teeth preserve a sliding contact, the condyles can move downward and forward from their most distal position a distance of 4 to 5 mm., with 12 mm. as the probable maximum. This is the extent of this movement which is important in prosthetic work. The paths of the condyles may be considered as straight lines, since any variation there-

[1] Quarterly Circular, C. Ash and Sons, December, 1901, p. 409.

from cannot be detected and is, therefore, negligible, and practically all articulators represent them as such. Now if the beginning and end of a straight line are located in space, the line itself is then located. Since the beginning of these paths of the mechanical condyles of the instrument have been definitely located with respect to the casts in the identical position of the anatomical condyles in relation to the jaws themselves by the face-bow transfer, it only remains to locate their other end and to adjust the condyle path guides to extend between these two points. By locking the path guides in this position we have established on the instrument the means of reproducing the movements of the patient's condyles in this direction.

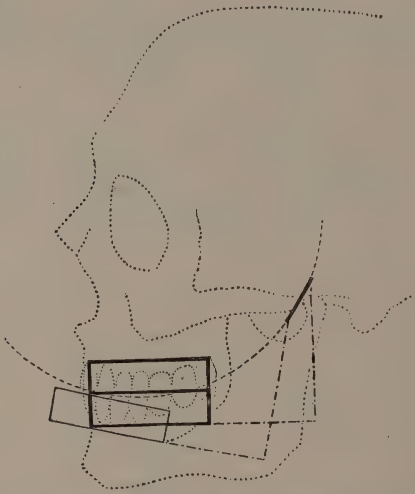

FIG. 127.—Schematic drawing, showing relation of dentures in position of occlusion and in forward position of mandible. (Christensen.)

After the casts have been mounted upon the articulator, the bite-plates are returned to the patient's mouth with a small lump of wax upon the occlusal surface of the lower plate near the rear on each side. The patient is now instructed to protrude the lower jaw and to bring it up in this position until the plates touch in front. If grooves have been made on the occlusal surface of the upper rim, the wax is forced into them, and when removed from the mouth the bite-plates may be adjusted together in this relation, giving us a record of the jaw relations in the protruded bite. During this procedure the patient's condyles have, of course, moved forward to the anterior end of their paths. If the bite-plates have been firmly fixed together by melted wax, staples or other means, they now furnish the means of adjusting the casts on the articulator to occupy the exact relations of the jaws in the protruded bite. The upper bite-plate is placed in position upon its cast and held there firmly by melting wax around its edges. The portions of the articulator which constitute the condyle path guides are loosened so they are free to move in any direction, and the lower cast may then be accurately fitted into its own bite-plate. When this is done, the mechanical condyles have naturally assumed the same relative positions as the anatomical condyles occupied in the protruded bite, or, in other words, they are at the anterior termination of their forward paths. It now remains only to securely lock these path guides in their present position.

This principle which has been widely adopted for the registration of the protruded bite, has been extended to registration of lateral bites and the adjustment of articulators in accordance therewith to reproduce lateral movements. A more accurate technic has been developed and it is by far the most satisfactory means now at our disposal for determining certain of the articulator registrations. Coupled with it as an essential check upon the registration of maxillo-mandibular relations, is the method introduced by Gysi of securing the so-called "gothic arch" tracing, which accurately indicates when the lower jaw is in the centric rest relation with both condyles returned to their most distal position.

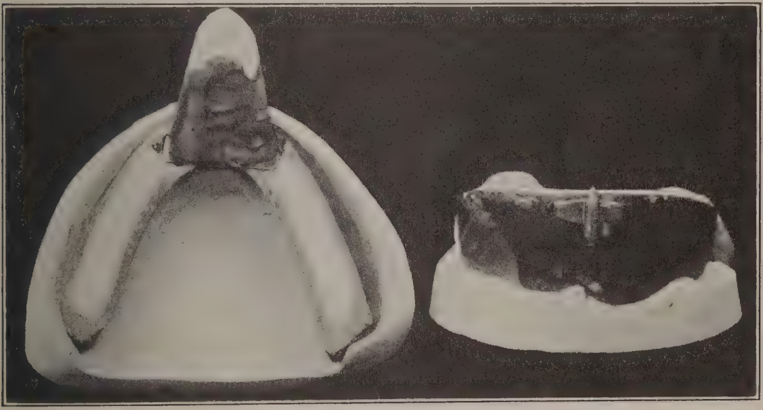

FIG. 128.—Bite-plates prepared for Gothic arch tracing.

Securing Centric Occlusion by the Gysi Gothic Arch Tracing.[1]—When introduced some years ago, the primary purpose of this technic was to secure records for setting the rotation centers of the articulator, but as noted at the time, it also served as "an excellent help in securing the normal resting position of the mandible." It is now relied upon as an absolute check upon centric occlusion.

After the bite-plates have been fitted to correct occlusal relations, a pointed marker fitting in a tube and actuated by a spring, is affixed to the labial surface of the upper bite-plate at the median line. It should project below the edge of the rim about 1 mm. A small metal plate is attached to the occlusal surface of the lower bite-rim as shown in Fig. 128. The upper surface of this is covered with a layer of black carding wax, and the bite-plates returned to the patient's mouth. (Fig. 129.) Before doing this it is well to cover the bite-rims with talcum powder so they will slide readily, one upon the other. The patient is instructed to press the rims lightly into contact, and then to slide the lower jaw directly forward and back again. The jaw must then be moved into right lateral occlusion and back, and then to left lateral occlusion and back, taking pains to see that it is not protruded in these movements. When this is carried out correctly, a figure resembling an arrow head (Fig. 130) will have been scribed upon the wax, its forward outline being somewhat the form of a gothic arch. When the pointed marker rests at the apex of this arch (the point of the arrow) the condyles are both in their most distal position, and the marking is a safe guide as to centric occlusion.

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[1] The Dental Cosmos, vol. **52**, p. 1 *et seq.*

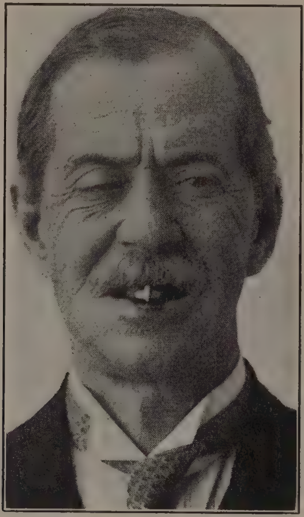

FIG. 129.—Bite-plates in patient's mouth.

Securing Records of Protruded and Lateral Bites.—For setting an adaptable articulator to reproduce mandibular movements in forward and lateral excursions, the technic has been well described by Russell W. Tench as follows:[1]

"The making of records for the registration of the masticating movements of the mandible in an articulator is a relatively simple operation.

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[1] Jour. Am. Dent. Assn., vol. **13**, p. 1675.

It requires the interposing, successively, between the occlusion rims, of two or three small rolls of compound when the patient holds the mandible in the closed right lateral, closed left lateral and, if desired, in the incising position.

"Compound is used for these registration guides rather than wax, because it sets to solid rigid form, which does not change. Its range and time of setting is greater than that of wax, and it is susceptible of more definite manipulation to control its hardness.

"The precautions to be observed in the technic are: (1) To see that the patient registers a true lateral position imprint without any protrusion component being introduced (the Gysi arrow point tracing is ideal for guidance in this operation); (2) to secure these records without exertion of enough force to unseat the registration plates.

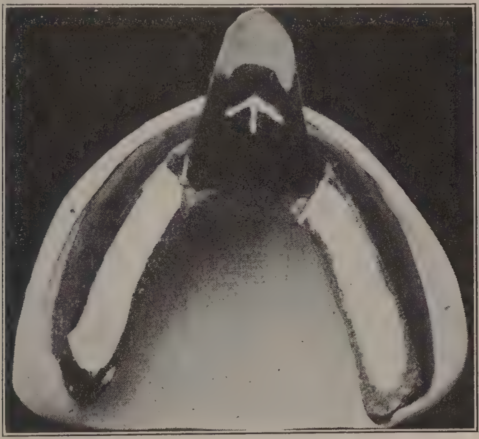

Fig. 130.—Gothic arch tracing on bite-plate.

"The method of securing the lateral bite registration consists in introducing a small roll of compound between the occlusion rims, then requiring the patient to shift the mandible to the right or left lateral position and when the tracing pin, by its relation above the gothic arch, indicates a true lateral occlusion position of about 5 mm., the patient is directed to close straight upward. The compound at this time should be only slightly resistant to pressure. The patient is directed to exert a small amount of pressure on the masticating side only; and to make no pressure on the balancing side. Both right and left lateral registrations are taken in the same manner.

"The protrusive relation of the mandible is recorded by requiring the patient to close upon a small roll of compound when the protrusive position of about 5 mm. is reached. It is advisable to register this relation with the anterior edges of the occlusion rims separated about 2.5 mm. or the equivalent of an average depth of over-bite.

"Following the registration of the protrusive and lateral occlusion contact positions, a face-bow record is taken. This is accomplished by covering the prongs of a Hanau face-bow mouthpiece, both top and bottom, with a mass of compound a little less than 10 mm. in diameter. When this has become set, the mass is introduced into the patient's mouth, between the occlusion rims. In this position, the patient is caused to close upon it so that a clean imprint of the occlusal surface of the maxillary rim is produced in the surface of the roll. When the compound has hardened, the face-bow is slipped onto the stem and the adapters are introduced into the external auditory meatus of the patient, locked at equal positions right and left, then lifted upward and forward into gentle contact with the top and front of the auditory canals. In this position, the face-bow lock nut is set tight. The face-bow is now removed.

"Right and left bite-lock impressions are taken in compound. The occlusion rims are to be in central occlusion position at this time.

"In setting the casts of the edentulous mouth into the articulator, the usual procedure is followed. The occlusal surface of the maxillary rim may be mounted parallel to the mandibular arm of the articulator.

"The mandibular cast is attached with sticky wax to the mandibular occlusion registration plate, and the two registration plates are fastened to one another in central occlusion by means of the bite-lock impressions and sticky wax.

"When the mounting of the casts is complete, the recording of the mandibular movements commences. The left lateral position registration is set between the occlusion rims, and the articulator mechanism is adjusted and locked so that the maxillary occlusion rim fits accurately into the imprint in the lateral registration form when this form is seated accurately on the mandibular occlusion rim.

"This operation is repeated for the right occlusion registration.

"Occasionally, it is found that the protrusive registration will require a different adjustment of the descending movement control from the lateral registration. The protrusive record is taken to determine whether this is so. If a difference in setting is indicated, the articulator is reset so as to produce the proper descending movement inclination when the articulation of the teeth is being inspected in, or perfected to, protrusive relations."

The only instruments at present available in which these registrations can be accurately made are the Hanau kinoscope (a somewhat more adaptable instrument than his Model H) and the Gysi Trubyte Articulator.

Hanau advises the use of protrusive bite-records for setting the condyle slants of his Model H device, and recommends setting the condyle standards to provide for the Bennett movement according to an experimental formula which need not be given here.

Securing Records Used in Setting the Gysi Trubyte Articulator.—Utilizing a principle which has been described by Norman S. Essig and

Alexander H. Paterson,[1] by which bite-plates carrying abrasives on their occlusal surfaces may be ground in the patient's mouth to curves providing contact relations, and employing other principles previously described, the Gysi instrument may be accurately set according to the following technic:

After the bite-plates have been trimmed and contoured to meet the esthetic and occlusal requirements of the case in hand, a shallow furrow is cut in the occlusal surface of each rim, leaving a narrow margin around the periphery (Fig. 131). This furrow is then filled with a mixture of equal parts of sand and plaster, or carborundum powder and plaster, and leveled off to a height of about 1 mm. above the original surface. When the plaster has hardened, the bite-plates are returned to the patient's mouth and he is requested to carry through the movements of mastication, sliding the bite-rims one upon the other. The abrasive incorporated with the plaster causes these bite-rims to gradually assume a curvature which permits an uninterrupted sliding contact between the plates in all of these jaw movements. To effectively accomplish this result, the bite-plates must be securely retained in place during the procedure.

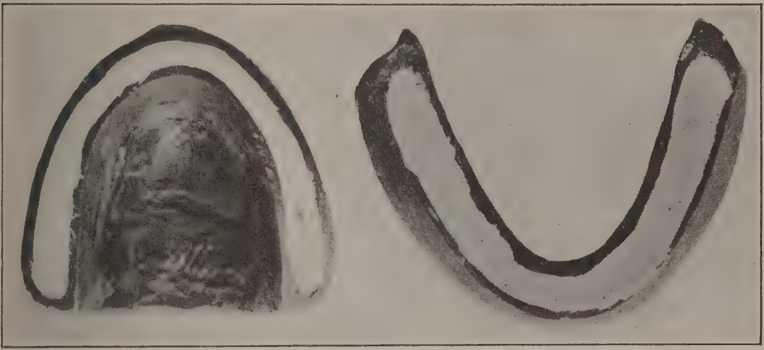

Fig. 131.—Bite-plate prepared for grinding in mouth.

The upper case may now be mounted upon the articulator by means of the face-bow, in accordance with the technic already described, after which the upper bite-plate is removed and preparations are made to secure the Gysi gothic arch tracing by the method given above. When this has been done, the bite-plates are locked together in centric occlusion, and the lower cast is now mounted upon the articulator in the usual manner.

With the bite-rims now ground to contact in the various positions of the mandible, and the gothic arch tracing completed, the lock-nuts controlling the adjustable condyle path guides of the articulator are released, and the lower cast is moved into the left lateral position following the arch tracing, and the bite-rims are pressed close together. In the execution of this movement, it will be found that the right condyle path guide has assumed a certain position or slant, and if locked in this position, it now reproduces the condyle path on that side. This procedure is repeated on the other side and the left condyle path guide correctly set. During these adjustments the incisal rod guide plane is moved so it does not interfere, as, of course, it is not concerned with these registrations.

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[1] The Dental Cosmos, vol. 65, p. 679.

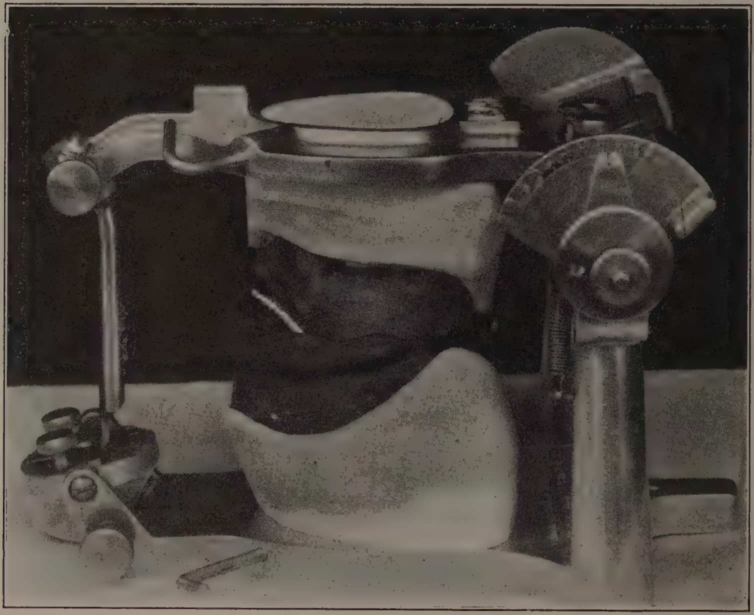

Fig. 132.—Adjustment of Gysi articulator to condyle paths by means of compound record of forward bite.

The bite-plates may now be returned to the mouth and lateral bites taken with rolls of modeling compound or wax as previously described. A protruded bite should also be taken to check with the registrations already recorded on the instrument. (Fig. 132.) In taking the lateral bites it is important to prevent any protrusive movements and the use of the gothic arch tracing to avoid this must be borne in mind. We are now ready to adjust the articulator to these records.

With the bite-plates carefully seated in position on the casts, the right lateral bite record is put in place and the lower bite-rim fitted to it. On the incisal guide plane are two adjustable plates which determine the movement of the incisal guide rod and fix the rotation centers of the mandible.

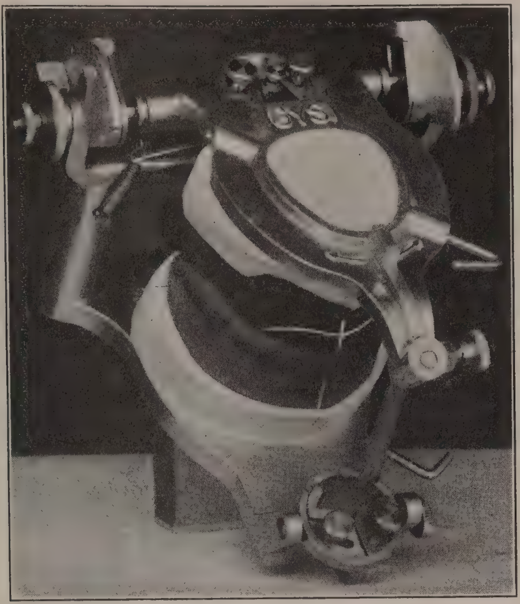

FIG. 133.—Adjustment of Gysi articulator by right lateral bite.

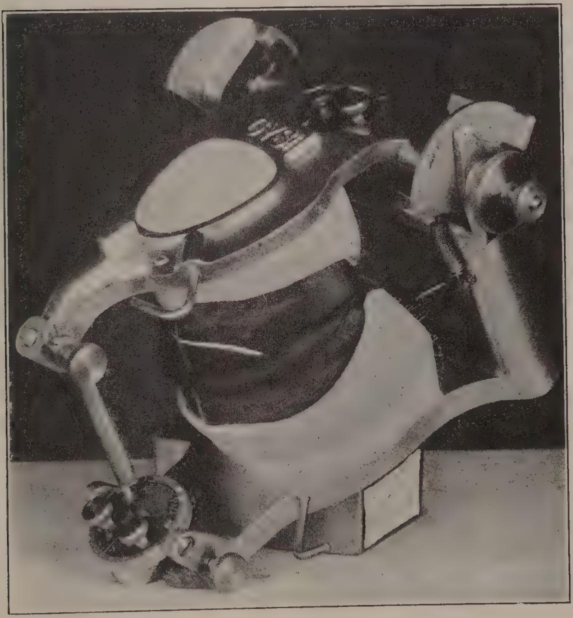

FIG. 134.—Adjustment of Gysi articulator by left lateral bite.

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In the center of the axis running through the condyles of the articulator is a circular plate with a roller bearing in its center, and upon this circular plate are located two adjustable segments which control what is known as the "Bennett movement" of the articulator.

Having the bite-plates in the articulator with the right lateral bite-record in position, the adjustable segment on the incisal rod guide plane on the right side is then moved into contact with the incisor pin and locked with the lock-nut, at the same time the adjustable segment on the left side of the circular plate controlling the Bennett movement, is brought into contact with the roller bearing and fastened by the lock-nut. (Fig. 133.)

The right lateral check bite is now removed and replaced with the left lateral check bite.

The bite-plates are now carefully adjusted in the left lateral bite, the adjustable segment on the left side of the incisor plate is then brought into contact with the incisal guide rod and locked with the lock-nut and the adjustable segment right (or reverse) side of the Bennett movement brought into contact with the roller bearing and the lock-nut fastened. (Fig. 134.)

If this technic is carried out accurately, the articulator will then be correctly adjusted for all movements of the individual jaw in question.

There now only remains the adjustment of the angle of the incisal rod guide plane, but as this is determined after the teeth have been selected, reference will be made thereto in Chapter VII.

CHAPTER VI.

THE PRINCIPLES UNDERLYING THE RETENTION OF FULL-PLATE DENTURES.

By CHARLES R. TURNER, D.D.S., M.D.

Before undertaking the design and construction of an artificial denture as regards its fulfilment of esthetic and functional requirements, it is necessary that an important fundamental mechanical demand upon it be satisfied. It is obviously essential that the denture shall be provided with a base of support that will be adequate to withstand the mechanical stress brought to bear upon it in use. Its support must be sufficient to resist the pressure applied in the crushing of the various kinds of foods. This resistance must be offered by the tissues upon which the denture rests without occasioning discomfort to the patient, and without being followed by retrogressive or pathological changes in the tissues furnishing the support. Furthermore, an essential condition to the satisfactory use of a denture is that it shall be firmly and stably maintained upon and in proper relation to its base of support. If it becomes dislodged, it cannot be used by the patient until it is again brought into its proper place. Its utility is seriously impaired if it is easily displaced; on the other hand, the more firmly it is retained *in situ* during use, the more effective its service to the patient will be. Arrangement for adequate support for the denture, and provision for its retention upon that base of support constitute separate problems and should be regarded as such. They involve two basic demands, which in point of time should receive consideration prior to all others in any systematic plan of denture design and construction.

Devices to replace natural teeth in the mouth derive their support from two sources—natural teeth or roots, and the mucous membrane covering the maxillæ and mandible. According to the source of this support, such prosthetic appliances are divided into the following classes:

1. Crowns—supported upon natural roots.
2. Bridge dentures.
    - *A*. Fixed—supported upon natural roots.
    - *B*. Removable.
        - (*a*) Supported wholly upon natural roots.
        - (*b*) Supported both by natural roots and mucous membrane.

3. Partial plate dentures.
    - *A*. Supported upon mucous membrane and retained by attachment to roots or natural teeth.
    - *B*. Supported by both mucous membrane, and roots or teeth—retained by attachment to roots or teeth.
    - *C*. Supported by mucous membrane—retained independent of attachment to natural teeth.
4. Full-plate dentures—supported by mucous membrane and retained by various methods.

The first two of these classes constitute so distinct a branch of prosthetic practice and involve principles of retention and support so peculiar to themselves, that they will be considered separately in succeeding chapters (XV and XVI). Partial dentures retained through attachment to natural teeth will be covered in Chapter IX. The present chapter deals only with full-plate dentures and partial dentures retained by means other than attachment to natural teeth.

Support for Plate Dentures.—The mucous membrane covering the maxillæ and mandible is normally firm, resistant and comparatively insensitive. It affords to a carefully adapted base-plate upon which are mounted artificial teeth, sufficient support to withstand the force exerted in mastication, provided the base-plate area is adequately proportioned to the number of teeth it carries and hence to the stress which devolves upon it in use. Under these conditions the support is afforded by the membrane without protest, and the underlying bony framework stands up under this unaccustomed pressure with very little if any retrogressive change. When dentures are first placed in the mouth, there may be evidence of a slight reaction on the part of the mucous membrane, though usually this is absent. Within a short time, the membrane develops a tolerance to the presence of a plate upon its surface, and if proper hygienic measures are followed to keep the plate clean and free from bacterial growth, fermenting food, etc., the membrane continues to exhibit an entirely satisfactory state of health. Lack of proper care of the denture, an imperfectly adapted base-plate, unevenly balanced articulation of the teeth, and great stress brought upon the plate by opposing firmly fixed natural teeth, all will stimulate retrogressive changes in the bony frame work. A frequently observed example of the influence of the last factor may be cited. A full upper denture is sometimes required for a mouth in which the natural lower anterior teeth remain. Unless a partial lower to restore the distal lower teeth is inserted, the whole force of occlusion is directed upon the anterior segment of the alveolar process under the upper plate, and resorption of the bone ensues from the local mechanical stimulation. The eventual result is an alveolar ridge, flattened when the natural teeth have opposed it, and covered with a mass of spongy soft tissue, but relatively unchanged under the distal parts of the plate. Such a condition is unfavorable for the stable retention of the denture and renders the adjustment of a future one more difficult.

For full dentures, upper or lower, there is usually sufficient surface for inclusion in the base-plate area to satisfy the demands of adequacy. Under a properly designed plate less change actually occurs than if the patient went without an artificial denture. It is a fact of common observation that resorption progresses more rapidly if no plate is worn, a fact attributable no doubt to mechanical stimulation through the crushing of hard foods between the alveolar surfaces themselves.

Partial dentures deriving their support from mucous membrane alone are more difficult to provide with sufficient base-plate area. In many cases of this type where the possibility exists, adjunctive support should be furnished by natural teeth through the use of occlusal rests or devices having the same effect. For a full discussion of this matter, the reader is referred to the chapter on Partial Denture Design.

As the satisfactory use of a denture for purposes of mastication depends upon its maintenance in position upon its supporting base, or, in other words, upon its retention, we shall now consider this phase of the subject.

THE RETENTION OF FULL-PLATE DENTURES.

In the sense in which it is used in this chapter, the term "retention" includes the utilization of all the various factors which have a favorable influence upon, and the avoidance or elimination as far as possible of all factors which have an adverse effect upon plate stability. In the beginning of our discussion, it is well to point out that this is not simply a problem for the dentist alone, but that a portion of the responsibility rests upon the patient. The retention of a plate denture involves one or both of two things. The first is a purely mechanical consideration—the use of some physical means to this end, which belongs in the province of the dentist. The second is dependent upon the patient and involves such coördination of the movements of the muscles of the mouth and jaws as will serve to maintain the plate and not displace it.

The dentist has at his command certain measures which he may institute, and it is his duty to utilize them to the fullest extent to which they will be serviceable. In many cases these are so effective as to require almost no assistance on the part of the patient. On the other hand, there are cases presenting mouth conditions which in themselves are so unfavorable for retention, that even the most skilfully constructed dentures will not exhibit adequate stability. In such instances the patient must supply whatever may be needed to overcome the natural disabilities of the case. In every instance something will be required of the patient, for it must be realized that an artificial denture is but a substitute for the missing tissues, and even under the most advantageous circumstances, the patient must learn to use this substitute in the manner in which such an appliance can be used.

It is almost never the case that when a plate denture is first inserted, the patient can at once eat with facility. The masticatory movements employed with the natural denture do not succeed so well with the artificial. The teeth are not firmly rooted in the jaws; they are mounted upon a less steady base which has to be maintained in place to be serviceable. The patient must develop a new method of mastication, one which is suited to the new condition.

Patients must learn to manipulate the food between the teeth, and to apply the force used in crushing it by such movements of the mandible as will tend to keep the dentures in place. This is often done by chewing on both sides simultaneously, and by using only the up and down motions of the mandible. A large number of full upper and lower dentures now in service admit of no other method of use, because of the form and positions of the teeth. It will be seen in a succeeding chapter that the teeth should be shaped and placed with a view of making possible the lateral movements of the mandible, which give more effective masticative results, and patients may thus acquire masticatory habits of greater utility.

Patients may often materially aid the retention of an upper plate denture by grasping its sides with the muscles of the lips and cheeks, and by manipulating the tongue to hold it or press it in place. These structures are susceptible of considerable education, for instances are of common occurrence in which the original physical means of retention have been rendered inoperative through alveolar resorption, and the patient has been forced to develop the use of this means to keep the plate in place. This factor doubtless operates to some extent in all cases. At times it may be desirable to make special provision to take advantage of this assistance, by making a rim-like projection around the buccal and labial margins of dentures to assist the tissues in securing a grasp upon the plate. In some cases in which the natural conditions of the upper jaw are unfavorable to firm plate retention, it is possible to extend this principle to the point of making decided projections on the buccal surface of the plate. The author has obtained a very satisfactory result from the use of this measure in a case of syphilitic necrosis, in which one of the antra was perforated, the entire alveolar process having been lost and the roof of the mouth being almost a plane surface. The use of springs in this case seemed inadvisable because all of the lower teeth remained intact. A vulcanite plate was made with a projection in the buccal region which avoided the anterior margin of the masseter muscle and which fitted into a depression in the cheek located above the position of the risorius muscle. The patient's cheek was somewhat distended by the appliance, but in the course of time a marked depression was made in the muscular structures of the cheek, and the patient learned to maintain the denture satisfactorily in place.

There can be no doubt that the cheeks, lip and tongue muscles have much to do with the holding of a full lower denture in place. Some lower dentures exhibit considerable adhesion, and of course the force of gravity is a favoring item, but generally speaking, lower dentures are not so stably retained as upper ones, and require more effort on the part of the patient.

In the case of lower dentures it is always advisable to so form them that they do not encroach upon the space ordinarily occupied by the tongue. In a case in which, by reason of resorption of the upper alveolar process, it is necessary to have a lower plate narrow from side to side in order that the teeth may articulate, it is advisable to make its lingual surface slightly concave; the tongue will not only fit into this space, but may, in a measure, assist in maintaining the plate in place by grasping the lower edge of the lingual surface. The extension of the distal portion of a lower plate lingually to produce a projection which may be grasped by the tongue has been recommended.[1] Where this extension would not seriously interfere with the movement of the tongue, and where in addition the tongue could obviously take advantage of the extension for the purpose indicated, it may be an advisable procedure.

In lower cases where retention of the plate promises to be difficult, and particularly where no form of partial denture has previously been worn, it is sometimes advisable to permit a tooth or teeth to remain, even when it is evident they will last but a short time. These are of great service in staying the plate and in keeping it in place upon the alveolar ridge, and serve to tide patients over that first period during which they are getting accustomed to the use of the appliance. Such teeth, of course, should be carefully preserved when they may be clasped and made of more permanent service, but reference here is made to those teeth only whose retention can be expected for a short time at best. It is impossible to estimate the value of this procedure to some patients, who, after having become accustomed to the use of the plate with the assistance of the natural teeth to maintain it, readily acquire the use of a full plate when the natural teeth are lost.

It should be carefully explained to a patient for whom full-plate dentures are made that the dentist can only make the plates retentive to the extent to which the conditions of the mouth permit. The former should be made to understand the nature and extent of his responsibility in acquiring the use of the dentures, and should be prepared to undertake the same. It is but a matter of simple justice to the dentist that this be done. On the other hand, the dentist must have done all within his power to provide for the plate's stability, and he has no right to pass over to the patient a handicap as the result of his own lack of knowledge or skill.

PHYSICAL FORCES INVOLVED IN PLATE DENTURE RETENTION.

The purely physical factors which influence the retention of a plate denture are as follows:

1. Certain purely physical forces.

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[1] Dental Cosmos, vol., 38, p. 41.

2. Correct plate outline and contours.
3. Correct occlusion and articulation of the artificial teeth.

The last two items are of great importance but they may be said to be partly negative in character because their determination in this connection must be so made that they have no adverse influence upon the plate's stability, but contribute directly to it.

Plate outlines and contours will be discussed in other portions of this volume, but their significance in the present relation will be considered later in this chapter. The methods of setting the teeth to best promote plate retention are given in detail in a succeeding chapter. Suffice it to say at this point that they must be arranged to receive the force of mastication in such direction as will not displace the dentures through leverage, but on the contrary, will serve to maintain them *in situ*. Briefly it may be stated that this is accomplished by setting them directly over the alveolar ridges, and by arranging for a balancing contact of the two sides during the various jaw movements.

The purely physical forces which are utilized as positive means of retention are adhesion, atmospheric pressure and gravity. Adhesion operates in the case of both upper and lower dentures, atmospheric pressure is sometimes employed for upper dentures, and gravity assists in the maintenance of lower dentures only.

FULL UPPER DENTURES.

Adhesion.—This may be defined as the molecular attraction existing between the particles of two bodies whose surfaces are in contact. It acts between two solids whose surfaces accurately fit together, or between a solid and a liquid, or a solid and a gas. The force of adhesion is directly proportional to the area of the surfaces in contact, and it offers the greatest resistance to a force tending to separate these surfaces by acting at right angles to them. Contact of the surfaces is essential to the maintenance of the adhesion, since the moment they are separated, the adhesion is broken up. Adhesion is of value more or less in the retention of all plate dentures, full or partial, upper or lower. It is of particular service in the part which it plays in the retention of upper dentures.

The retention of upper plates by this means presents a number of interesting points for consideration. The problem is to make a plate, covering the area contained within the plate outlines, which shall have the greatest adhesion, and hence offer the greatest resistance to a displacing force. Other things being equal, the plate area should be as large as possible, since the adhesion is proportional to this area. The area is limited solely by the necessity for not encroaching upon tissues whose movements would result in the displacement of the denture.

The outlines and contours of a plate should not encroach upon tissues whose movement will result in unseating it. It is not always possible to avoid laying the plate outlines down upon areas not subject to some motion; in fact, it is often desirable to extend them to such areas in order that they may rest upon relatively soft tissue. In such instances the end must justify the means, and the better adhesion thus secured, must fully counteract the adverse effect of the moving structures.

For a full upper denture the boundaries of the plates should be as follows (Fig. 135): Beginning at the median line of the mouth, the plate outline should be placed low enough to avoid the frenum of the upper lip. It should then ascend into the incisive fossa below the line of reflection of the mucous membrane from the alveolar process to the lip, and over the canine eminence at a somewhat higher level, until it reaches the interspace anterior to the first bicuspid, when it descends to avoid the anterior margin of the buccinator muscle. It will be remembered that there are no muscular attachments to the maxilla in the incisive fossa and over the canine eminence, and, as this underlies a portion of the face which will require considerable support from the denture, the plate outline may be carried proportionately higher here than elsewhere. From the anterior border of the buccinator, the boundary must be low enough to give full play to this muscle, and the several plicæ or folds of the mucous membrane extending between the process and cheek, commonly observed in this region, must be avoided. When the tuberosity is reached, the plate outline may again ascend to a higher level, rounding it to reach the palatal vault. It must be remembered that the anterior margin of the masseter muscle is about opposite the second molar tooth, so the plate contours in this region must avoid it. This description is intended to give the student the anatomical landmarks for the periphery of a full upper plate. The method of automatically molding the plate margins through the action of the muscular structures upon the edges of a modeling compound impression is described in the chapter on that subject and the reader is referred to Chapter III for details.

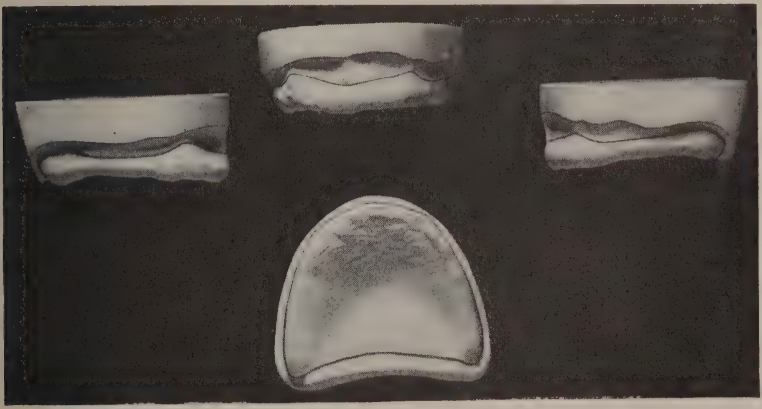

Fig. 135.—Conventional outline for full upper denture.

Besides giving a plate of the greatest possible area, another thing is accomplished by having the plate outline follow this course along the labial and buccal surfaces of the alveolar ridge. This provides for the exclusion of air around this part of the periphery of the plate, a condition which we have seen is necessary for adhesion. The lips and cheeks thus form curtains to cover the edge of the plate, and they constantly act as barriers to the ingress of air. So long as the lips and cheeks are closely applied to these portions of a denture, the plate may be pulled upon in front with considerable force without the admission of air at the margins and the consequent breaking up of its adhesion. This is especially true if the alveolar ridge is pronounced and has not been resorbed and the soft tissues are attached to it externally at a high level. It is generally known that the maxillæ most favorable to the stable retention of a plate denture, other things being equal, are those in which the alveolar process is well defined and which have a broad high vault. A high-pointed vault affords conditions less favorable for the secure attachment of a denture, because the plate more readily slides upon the slanting sides of the vault, the ordinary displacing tendency not acting at a right angle to such surfaces; while a flat mouth, in which the ridge has almost entirely disappeared, is, of course, less favorable, because of the easy access of air to the plate edges. In proportion, however, as the tissues are attached at a high level on the buccal and labial surfaces and there has been small resorption of the ridge, is it possible to make retention secure. Closeness of the contact of these plate margins to the alveolar ridge may be accentuated by measures to be discussed later.

The posterior margin of the plate should be far enough forward to avoid any possible displacement caused by the movements of the soft palate. This line corresponds in some mouths with the end of the hard palate, while in others it is considerably anterior to this. The line of movement may be observed by having the patient open the mouth and pronounce the syllable "ah." As this is the part of the periphery of the plate where it is most difficult to exclude the air, it is desirable to have the plate extend back until its margin is laid down on soft tissue and its contact therewith accentuated by suitable impression technic. It is also desirable to avoid contact of the plate margin with the distal end of the hard median ridge, although this is not always possible. In cases of extreme difficulty it is, therefore, permissible to have the plate outline slightly encroach upon the movable area, so slightly, however, that the advantage obtained in the matter of the exclusion of air is not outweighed by the displacing influence of the palatal muscles. This advantage should be gained always where the softness of the alveolar process anteriorly permits a rocking of the plate and hence a displacement under stress in the rear.

The adhesion of all full upper plates may be increased by accentuating the contact of their periphery with the mucous membrane. This is brought about in two ways: By the employment of a definite technic in the use of modeling compound for the impression as described in Chapter III, and by modifying the cast secured from a plaster impression. A judicious alteration of the face of the cast to effect this purpose is not only permissible, but is indicated in cases for which the impression has been taken in plaster. It should be done as follows: The cast should be compared with the mouth and the plate outline drawn upon it as described above. Then the tissue underlying the periphery of the proposed plate should be carefully examined digitally to estimate its compressibility. This is to determine how much it may be safely compressed by the margin of the plate. In some mouths the mucous membrane around the buccal and labial alveolar walls is so dense, or thin, or closely adherent to the underlying bone, that it will bear only slight compression, while in others it is soft and may be compressed perceptibly without protest. The cast (Fig. 136), should be slightly scraped along these corresponding areas, so that when the plate has been formed upon it, or upon a die made from it, the contact of the plate margins will be accentuated. The amount to be removed from the cast is slight even in cases requiring the greatest alteration, and around the buccal and labial walls never exceeds $\frac{1}{100}$ to $\frac{1}{50}$ inch in thickness. Across the palatal vault at the posterior margin a greater amount may be removed. This, of course, is with the exception that the hard median ridge must not be pressed upon unduly by the plate, and it is best not to scrape the cast at this point when the ridge is included in the outline.

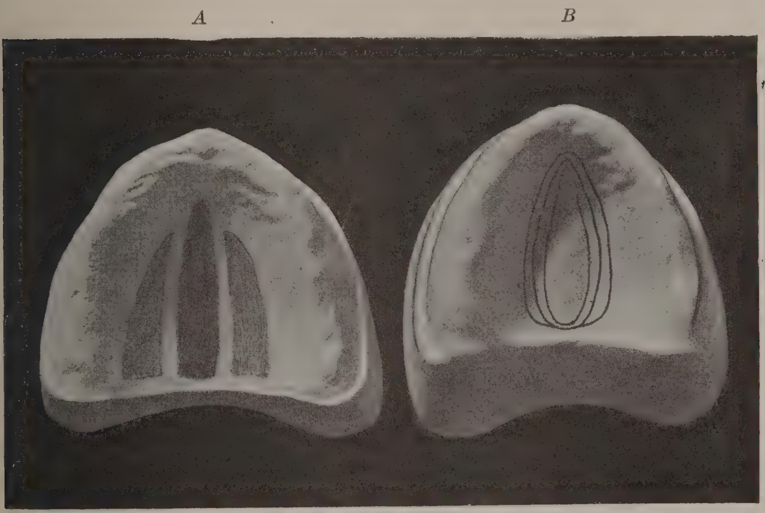

Fig. 136.—*A*, full upper cast showing hard areas heavily shaded and soft areas lightly shaded; *B*, full upper cast showing hard median ridge, with lines drawn to show sizes of three layers of tin-foil to be added for purposes of retention.

At one time it was the custom to raise a well-defined bead around the periphery of a plate by cutting a shallow groove in the cast just inside the plate outline, but with the development of an impression technic to accomplish an accentuation of marginal contact it is now seldom employed.

The rationale of the action of this measure in maintaining adhesion is as follows: The plate is drawn into place by pressure, and by the withdrawal of the air beneath its surface through suction produced by the tongue and throat muscles. When all the air has been withdrawn and the plate adheres to the surface, the tissues around the periphery are slightly compressed. As they are elastic and tend to assume their normal position, they follow the margin of the plate as it is pressed away from them under stress, and thus maintain for a greater time the contact of the margins. In the course of time under the continued pressure of the margins, the tissue underlying them becomes resorbed, and this elasticity is lost, but the plate margins are then slightly imbedded in the membrane and the ingress of air is more difficult. It must be understood that the plate should press but slightly more around its periphery than elsewhere, and it is not desired to make such alterations in the cast that the plate covering the other portions of the mouth is held off by the contact of its periphery. This would make a vacuum-chamber of the whole plate, a result not to be desired. Nor is it advisable to accentuate this marginal contact to such an extent that the tissues underlying the margin are compressed beyond their tolerance. This sometimes happens in the taking of impressions with modeling compound through too zealous a desire to obtain good retention. The plate when first inserted exhibits remarkable adhesion, but in a few days irritation of the tissues thus compressed demands a relief of the marginal pressure.

The adhesion between a plate and the mucous membrane would be a comparatively simple matter if they were two flat and unyielding surfaces. As it is, the surfaces are irregular, and one, that of the mucous membrane, offers varying resistance to pressure over the different portions of its surface. This, of course, is due to both the density of the membrane and to the amount of tissue intervening between it and the bone. The skeletal foundation is hard and resistant, but the membrane varies normally in density, and in abnormal conditions this variation is even more striking.

In a vast majority of mouths the median line of the upper jaw presents a hard ridge, which is due to the close adhesion of the overlying tissue to the suture between the two maxillary bones, which extends some distance forward as shown in Fig. 136, *A*. The alveolar ridge is normally much less resistant and its soft tissues are less adherent to the bone. On each side of the median suture the areas which occupy the posterior half of the vault are softer than any other portions of the jaw. This distribution of the resistance of the tissues which is typical of that found in most cases, is often varied, and it will be seen that there is never an equal resistance to the pressure exerted upon a plate over the whole area covered by it, even in mouths which are most favorable for the use of a plate denture.

In about 1 per cent of upper jaws there is a fissure instead of a ridge along the median line, and in others this part of the mouth is the seat of a hard bony elevation.[1]

While the whole area covered by the plate is more or less compressible, the soft underlying areas are the most so, and it will be noted that when pressure is applied to a plate made over a cast made from a plaster impression and accurately fitting the surface, it will bear harder upon the inelastic areas and may rock upon them. Thus pressure applied alternately upon the plate at the sites of the molar and bicuspid teeth will cause it to rock upon the hard median ridge, and if the tissues on one side are compressed until the other side is detached from the membrane, the plate will drop. It is evident that this should be prevented if possible.

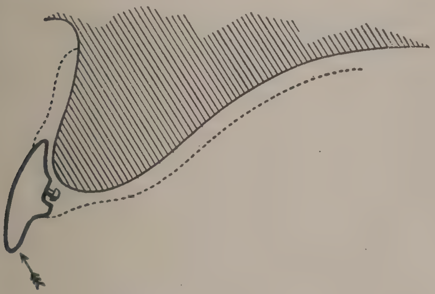

Fig. 137.—Diagram illustrating leverage upon incisors.

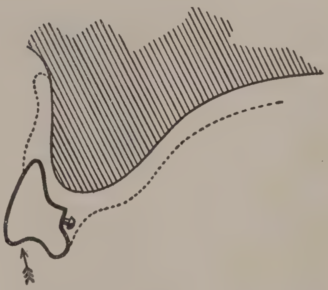

Fig. 138.—Diagram illustrating leverage upon molars.

Let us consider the direction of the force usually applied to an upper denture and those forces which tend to displace it. During the use of the plate the force of mastication is applied to it along the arch of the teeth, and, as these are approximately over the alveolar ridge or to its labial or buccal side, the ridge itself is the portion of the jaw which receives the pressure of mastication. If the force were applied to the plate along the whole line of the teeth uniformly at all times, as it is when the teeth are in close occlusion, the plate would be firmly pressed into place. But it constantly varies in distribution, amount, and direction, according to the position of the food between the teeth. The pressure received upon the incisors tends by leverage over the process in front to displace the rear of the plate (Fig. 137), while that upon the molars and bicuspids tends to depress the opposite side by leverage (Fig. 138). It is evident that an advantage would be gained if the tissues were uniformly compressible, but this condition never exists. However, if the pressure of the plate upon the hard areas is relieved, and it is not permitted to bear upon them under force until the soft tissues have been compressed into a like resistance, the same object will be accomplished. It is possible to construct a plate which will do this.

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[1] Haskell, L. P.: Items of Interest.

As outlined in the chapter on Impressions, a cast obtained from a modeling compound impression properly taken, represents the soft areas of the jaw as being compressed and in this manner the desired equilibrium of resistance may be established. Other methods are necessary when plaster alone is used for the impression, and the most satisfactory way to effect the desired result is by making addition at the site of the hard areas to the cast upon which the plate is to be made. A cast made from a plaster impression, which accurately represents the hard and soft areas alike, no compression of the latter having occurred in securing the impression, is compared with the mouth, and the hard areas, having been located by a careful digital examination, are relieved on the cast by additions to its surface. When the plate is to be made directly upon the cast, as in vulcanite work, the additions may be most exactly made of layers of tin-foil No. 60, cut to size, and laid on to the necessary thickness, usually about three layers being required. These are made to adhere with liquid silex. On a cast to be used as a model for a die, wax may be used for this purpose. The standard of compressibility ought to be the normal alveolar ridge upon which the tissues are healthy and supported by bone. The hardest areas are to be covered most thickly, that along the median line in an upper jaw being usually the one requiring most attention. Bony tuberosities in the median line, as in Fig. 136, *B*, or those located elsewhere should always be relieved in this way. Some operators prefer to accomplish this end by scraping from the impression at these points, but this does not seem so desirable a procedure, for the reason that it is more difficult to judge of the amount taken from a surface than of that added to a surface, particularly inasmuch as in the method above described the thickness of the additions may be always measured.

As there are areas harder than our standard of compressibility, so there are areas softer, but these do not concern us except as they are located at places at which the force of mastication is received. The soft area in the posterior third of the vault on either side of the median line does not need any compression by the ordinary plate, although the contact of the edge of the plate therewith should be accentuated. The alveolar ridge itself is quite soft in some cases, the tissues being spongy and flabby and easily compressible (Fig. 139). This condition frequently results where the teeth have been lost through pyorrhea alveolaris, the alveolar process having been considerably resorbed before the teeth are finally lost, leaving a very low ridge covered with a thick mass of soft tissue.

It is evident that it is a serious disadvantage to have soft compressible tissues underlying the plate at the very position at which the force of mastication is received, and it is in these cases that it is most difficult to obtain firm retention. The soft tissues yield under pressure, permitting the plate to bear upon the harder portions of the vault with a consequent tilting and dropping.

The measures usually employed to combat this condition are the alteration of the face of a cast which accurately represents the hard and soft tissues in their normal relation, or the taking of an impression of the jaw with some material requiring force in its application which shall compress the soft tissues and thus yield a cast with these tissues compressed as they should be under the plate. In the first of these measures the cast is scraped or carved at portions corresponding to the soft areas with a view to representing them as compressed under the plate. This requires much judgment, and is generally a dangerous thing to undertake, but with care a satisfactory result may be obtained in cases in which only the alveolar ridge or certain parts of it are soft. The cast is compared to the tissues and the carving done only after a careful estimate of the amount to be removed.

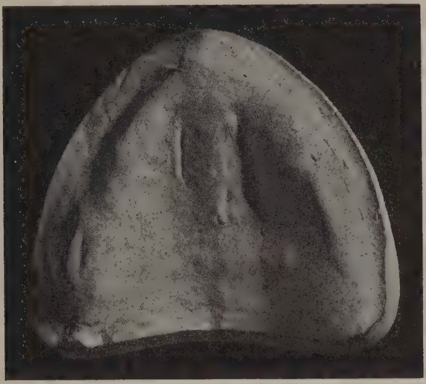

Fig. 139.—Very flat upper jaw in which plate retention is difficult.

The methods of taking the impression to obtain a cast representing the soft tissues compressed are described in Chapter III. It must be remembered that in addition to compressing the soft structures of the ridge, there is danger of also displacing them, and this must be guarded against, or must be remedied by an alteration of the cast. The soft gum tissue is pressed outward as the impression material is carried home, and the cast must be slightly scraped on the buccal or labial aspect of this soft portion of the ridge. Each of these measures is open to the objection of inaccuracy, but a full recognition of the danger which might result from improper alteration of the cast and a careful examination of the mouth in comparison with the cast and the making of alterations to accord therewith, will sometimes warrant the procedure. It is seldom possible to depend upon this measure as the only one to promote the retention of the denture, and it must be supplemented in most instances by the addition of a vacuum-chamber, in cases of this type the retention is so difficult that advantage should be taken of every means to promote it.

It has been recommended in very difficult cases of this character, in which the whole alveolar ridge is covered with a pendulous mass of soft tissue, that this be removed surgically under novocain anesthesia. This course is the indication where adhesion cannot be obtained without it, and it may be said that the adjustment of the plate will be simplified by such an operation. The procedure as advocated by Ruyl[1] is described by him as follows: "Instead of beginning at one side of the ridge and cutting entirely across to the other side, begin in the center of the soft tissue and cut on one side almost to the end, leaving only enough attachment to prevent the flap from dropping; then begin from the center again and cut entirely across to the other side. The flap will now be suspended by a small piece, which can easily be clipped off. By doing this we prevent the flaps from getting in the way while operating. In these cases healing takes place so rapidly that impressions can be taken in a week or ten days."

The surgical preparation of the jaws at the time the teeth are extracted in order to reduce the time before an artificial denture may be inserted, and to provide a better base for the denture, has come somewhat into vogue in the past few years. The measures employed usually consist in reflecting the muco-periosteum with a periosteal elevator, starting at the crest of the alveolar ridge and fully exposing its summit, after which, with suitable surgical burs and chisels, the prominent septa are removed and the crest of the process somewhat reduced in height and rounded over to the form which the alveolar ridge would assume after the lapse of several months. The soft tissues are replaced and sutured together if necessary. By this means the period of waiting for the resorption to take place is avoided, and if the trimming has been well done, a very satisfactory base for the denture is secured. It undoubtedly materially shortens the time which must intervene before a denture can be inserted.

Atmospheric Pressure.—Atmospheric pressure is utilized in the retention of upper plate dentures by the partial exhaustion of the air from a space made for this purpose in the portion of the plate in relation with the mucous membrane. This space is known as the vacuum-chamber. The principle has been in use in dentistry for a long period of time, the first recorded instance of its use in the United States being that of W. H. Gilbert, a confectioner of Hartford, Conn., in 1840. A vacuum-chamber of somewhat different form was patented by Dr. John A. Cleveland of Charleston, S. C., in 1850.

The partial exhaustion of the air from the vacuum-chamber causes the pressure of the atmosphere upon the lingual surface of the plate to sustain it *in situ* upon the jaw. The air is withdrawn from the cavity by the patient by the use of the tongue and throat muscles. A partial vacuum is created in the portion of the mouth just back of the plate and the air is drawn out from beneath it. The vacuum can never, of course, be perfect and it is believed that in a large majority of cases the air in the chamber is only very slightly rarefied.

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[1] Dental Cosmos, vol, **40**, p. 414.

The use of the vacuum-chamber principle has been the subject of considerable discussion in dentistry, some practitioners having great faith in its permanent utility, whereas others believe that its use is but temporary and uncertain, and consider its attendant disadvantages to greatly outweigh its usefulness. It is argued by the opponents of the principle that in the course of time the mucous membrane is drawn into the depression in the plate, thus wholly or partially obliterating it, and in consequence destroying the utility of the device. They also argue that the irritation of the soft tissues caused by the pressure of the edge of the vacuum-chamber and that occurring over the area covered by the chamber, are serious drawbacks to its use.

The advocates of this principle maintain that in the beginning the adhesion of all upper plate dentures is increased by the use of the chamber; that, even if it is of only temporary utility, the stability of the denture thus acquired tides the patient over the period in which he or she is getting accustomed to the appliance. They also argue that, despite the drawing of the mucous membrane into the space, this cavity is never completely filled, and it is always possible to get some pressure from the atmosphere in consequence. They further add that a space located over the areas ordinarily hard in most mouths produces a relief of the pressure of the plate at these points.

The vacuum-chamber has become too well-established a principle in dentistry to believe that it will ever be entirely abandoned. It probably has a certain field of usefulness and this is gauged by a balancing of its evident advantages and disadvantages in favor of the former. It is safe to state that the present methods of impression taking have so greatly improved the retention of upper plates by adhesion alone, that there are comparatively few cases where the vacuum-chamber is indicated. To obtain the most satisfactory results from its use, careful attention must be paid to the detail of its form and location, and to the avoidance of all measures which tend to emphasize its attendant disadvantages.

The following method of its location is quoted from Burchard: "The slight movement usual with a plate during mastication tends to separate it from the mucous membrane and permit the access of air to its under surface.

"The line of least movement, as the movement is lateral, a rocking from side to side, is along the median line of the vault; and, as the concavity of the hard palate is usually of an irregular vault form, the point of least movement is near its apex. If the movement does not extend to an edge of the chamber, the stability of the plate is not materially affected, but when one of these edges loses its contact, air enters the chamber and adhesion is destroyed.

"The more closely the edges of the chamber approximate this line, the less tendency to disturbance there is, so that comparatively narrow chambers are to be preferred; but the depression should be of sufficient size to not materially lessen the effects of a partial vacuum. Naturally the chamber should be in the area of greatest stability, that of least movement. This area will be found around and about the center of gravity, and in shape resembling the outlines of the dental arch."

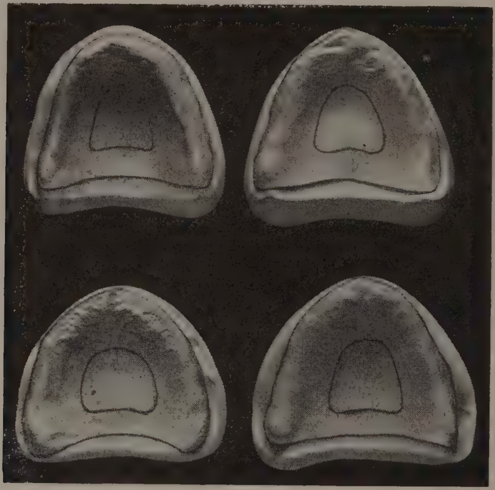

Fig. 140.—Cases with plate outline and form of vacuum-chamber marked upon them.

There should be a general correspondence in the size of the vacuum-chamber, and the palatal vault and its outline should carefully follow the general outline of the alveolar ridge. It is desirable as far as possible that the distal edges shall not be laid down in very soft tissue, nor should the anterior edges impinge forcibly upon the rugæ. Fig. 140 illustrates the manner in which the form of the vacuum-chamber should correspond to that of the alveolar ridge.

The vacuum-chamber should inclose within its area any hard bony elevation which may be found along the median line of the vault, provided this would not carry the edges of the chamber too close to the posterior margin of the plate, or make the chamber unduly large. Where a chamber is to be used in a mouth with a hard median ridge, the form illustrated in Fig. 141, *B*, is recommended by many practitioners. The edges of such a chamber are nearest to the line of least movement of the plate, and the hard median ridge is relieved.

In order to be effective, the edges should be square but not sharp. Unless there is a positive contact between them and the mucous membrane, the air will readily obtain ingress into the partially exhausted chamber. On the other hand, they should not be so sharp or prominent as to cause irritation of the membrane from pressure. The sides of the chamber should extend in lines perpendicular to the tissue upon which the edges rest.

The most serious evil consequences follow the use of chambers which are too deep or too large. It has been found by experience that in the softest mouths the air-chamber should be slightly deeper than in mouths with firm and resistant tissue. The vacuum-chamber for the soft mouth should not be approximately thicker than No. 14 (B. & S.) gauge, while that for a hard mouth should not exceed gauge 16 in thickness.

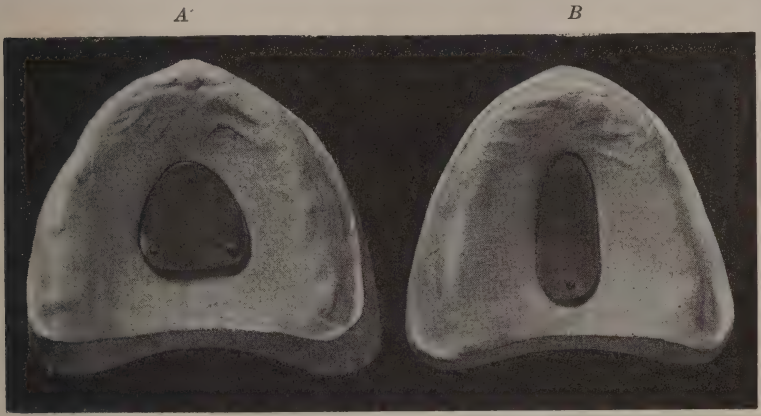

Fig. 141.—*A*, vacuum-chamber form fixed in position upon upper cast; *B*, long vacuum-chamber form for use in a mouth with long, hard median ridge.

The vacuum-chamber will be found useful in all cases in which the anterior alveolar ridge is very soft, without a corresponding softness of the palatal vault and distal portions of the ridge. It may be used to advantage in very flat mouths of all sorts. It should be used in all temporary plates where the labial portion of the plate is omitted, the artificial teeth resting directly upon the gum. It is also of service in the retention of all partial upper dentures not held in place by means of clasps.

To form the chamber in a vulcanite plate, any vacuum-chamber form cut out of chamber-metal may be applied to the cast. Chamber-metal consists of a sheet of lead with tin-foil on each side; thus it has the softness and pliability of lead, while its surface is protected from the action of sulphur in vulcanizing by the coating of tin. Having been cut to proper shape, the form is burnished to the surface of the cast and held in place by three pins inserted, one at its apex and one at each of its distal corners. In the preparation of the cast as a model for a die, the air-chamber form is pressed into place and made to adhere by means of melted wax. The point of juncture of the periphery of the vacuum-chamber form and the cast should be so distinct that, when the plate is produced, this edge representing the edge of the vacuum-chamber will be well defined.

THE RETENTION OF FULL LOWER DENTURES.

Full lower dentures present a more difficult problem to the prosthetist in regard to their retention than do full upper ones. They are retained partly by their weight and by adhesion to the mucous membrane, but in many case these physical forces do not provide satisfactory maintenance, and the patient must furnish supplementary aid through the muscular structures of the lips, cheeks and tongue.

Adhesion.—Since the development of the modeling compound technic for impression taking it has been possible to endow lower plates with a degree of adhesion formerly thought impossible, and in favorable cases the adhesion is so strong as to compare favorably with that possible in upper dentures. The fact that the base-plate area is so much smaller than in upper plates, and that its margins are not so effectively protected against the ingress of air by the lips and cheeks, and the further fact that the alveolar ridge is relatively much less prominent in the lower jaw, make adhesion more difficult to secure. Furthermore, the tissue covering to the mandible in relation with the buccal and labial margins of the denture is thin and intimately attached to the bone, so accentuation of the marginal contact cannot be so effectively carried out. The actual height of the alveolar ridge is usually much less than in the upper jaw, which constitutes another less favorable item in the problem.

In developing the maximum adhesion for a full lower plate, it is necessary to study carefully the location of the plate margins. Following the basic principle that these must be laid down in areas which are not subject to movement from muscular contraction, the plate outline must be located with regard to certain anatomical landmarks. Around the labial and buccal borders and starting at the median line, the attachment of the levator labii inferioris is to be avoided; then the depressor anguli oris, platysma and buccinator come in the order named; though the last is the only one attached near the plate margin. In this buccal region there are generally folds of mucous membrane extending from cheek to process which must be avoided as they are stretched by the cheek muscles and may impinge upon the denture's margins.

As the posterior termination of the lower plate is reached the plate outline should extend as far into the soft tissues back of the former position of the last molar, the so-called "retromolar space," as possible. This soft tissue offers the opportunity of having the contact of the denture's margins therewith sharply accentuated, which will serve to maintain contact and exclude air at this critical point. The margins should extend as far backward and upward as possible, without, however, reaching the tissues which are subject to movement, and without coming into contact with the upper base-plate when the mouth is closed.

The mylohyoid muscle forms the floor of the mouth in an anatomical sense, being attached to the mylohyoid ridge on the inner side of the mandible. The inner margin of a lower plate should extend as far downward as the attachment of this muscle with its overlying tissue will permit, but, obviously, there must be no impingement upon it or the tissue moved by it. At the median line, the frenum of the tongue must be given free play.

The great advantage which the molding of the softened margins of a modeling compound impression by the actual pressure of the muscular structures which are in relation thereto, cannot be overestimated in securing a proper outline for a lower denture. If this is not sufficient to develop an impression that will remain seated during its trial, it may be necessary for the operator to further mold these margins by pulling upward the lips and cheeks, while the impression with its margin softened is held in place upon the alveolar ridge. The inner margin may be tested and, if necessary, adjusted by softening it and having the patient touch the roof of the mouth with the tip of the tongue as far back as possible.

The peripheral margins of dentures must be rounded so they will present an edge which will not cause irritation, but in lower dentures especially, this margin must not be too thick. The margin itself may have been located at the proper place, but if it is too bulky, it may come under the displacing influence of the muscular structures.

In a case with a very thin narrow alveolar ridge, especially if its crest is covered with soft tissue, there may be a tendency for the plate to ride on this ridge and poor adhesion will result. Relieving this pressure in the impression and readapting it will remove the difficulty.

In many mouths in which the alveolar ridge has almost completely disappeared, and in which the denture rests upon rather soft tissue, good adhesion may sometimes be secured by extending the buccal and labial margins as far outwardly as possible so that the lip and cheeks will hug them closely and exclude the air. A denture made on this plan has a larger base-plate area than is commonly employed. These outer margins must be molded accurately in a modeling compound impression; they actually rest on tissues subject to slight movement, but if the adjustment is carefully made by repeated molding and remolding, the denture made from such an impression will exhibit a gratifying amount of adhesion.

The muscles of the tongue, lip and cheeks are important factors in the maintenance *in situ* of many full lower plates. When a good alveolar ridge exists and satisfactory adhesion has been developed, their assistance may be more passive than active. As adhesion begins to wane, they are called upon more and more, and they acquire a very great usefulness in holding the denture upon its base and in returning it thereto if it is displaced. Where the physical forces of retention are ineffective at the beginning of the use of the denture, it devolves upon these muscular structures to develop the method and the means of holding the plate in place, and with some patients, this is a long and tedious process and requires patient perseverance.

Because of the fact that, naturally, retention is poorer in lower plates, it is very important that the lower teeth should be mounted as nearly directly over the alveolar ridge as possible to avoid any displacing influence of leverage. It is also very necessary that the lingual contours of the plate should not encroach upon the space occupied by the tongue and thus interfere with its free movement.

Gravity.—While the force of gravity is naturally a favorable factor in lower plate retention, its value has been somewhat overestimated. The use of weighted dentures to increase its effect in a given case has not been very satisfactory. A lower denture in which the other factors of retention have been developed to their utmost is usually most comfortable for the patient if it is light in weight, and excessive weight is decidedly uncomfortable. Furthermore, excessive weight stimulates the resorption of the underlying bone and is objectionable on that score.

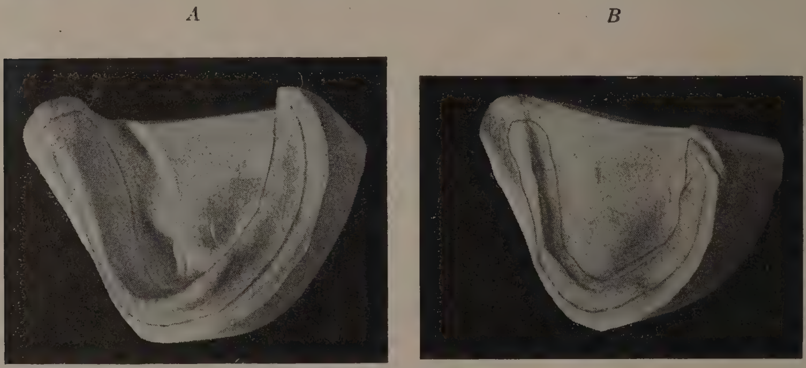

FIG. 142.—*A*, Plate outline for full lower cast with well-defined ridge. *B*, Plate outline for full lower cast with little ridge.

THE RETENTION OF PARTIAL DENTURES.

Partial Upper Dentures.—These are maintained in place by adhesion, by atmospheric pressure and by attachment to natural teeth or roots.

Adhesion is only of material service in cases in which the area of the base-plate is relatively large. Its value is limited by the fact that the plate margins are not all protected against the ingress of air, as at the site of natural teeth it is difficult to exclude it. Therefore, adhesion is inadequate as the sole dependency for retention of partial plates and it merely serves in an adjunctive capacity.

When the choice of means is available, retention through attachment to natural teeth is to be preferred, as this not only provides much greater stability for the denture but it permits the use of a plate of much smaller dimensions, which is very desirable. As this method of retention is discussed in detail in a succeeding chapter, no further mention need be made of it at this point.

There are certain cases, however, requiring a partial denture in which it is not possible or advisable to utilize the remaining natural teeth to maintain the denture, in which event it is necessary to put a vacuum-chamber in the plate which, together with such adhesion as may be obtained, serves to support it. A plate to supply all the upper teeth back of the six anterior teeth may be cited as an example. To use these teeth to support the denture would be disastrous, as the leverage upon them would soon occasion their loss. When used, the vacuum-chamber is to be designed and located in accordance with principles given earlier in this chapter.

Partial Lower Dentures.—The base-plate area of these dentures is so small that adhesion normally plays a very small part in their retention. Attachments to natural teeth through clasps and other devices should always be employed and the reader should consult the chapter on Partial Dentures for details. However, when the area of the base-plate is sufficiently large to warrant it, as in plates supplying all the distal teeth, adhesion may be developed in a limited degree by following the correctable modeling compound method of impression taking.

Gravity, of course, renders some additional service in retention, but it merely supplements the other means employed.

CHAPTER VII.

THE SELECTION, ARRANGEMENT, AND ARTICULATION OF ARTIFICIAL TEETH.

By CHARLES R. TURNER, D.D.S., M.D.

AND

FRANK A. FOX, D.D.S.

In a general way it may be said that the purposes of artificial dentures are the restoration of the impaired functions and the altered facial appearance which have ensued from the loss of the natural teeth. Artificial dentures should restore any lost parts of the mechanism concerned in the preparation of food for subsequent stages in its digestion, or should establish a satisfactory means for the execution of this function. If the normal voice and articulate speech have been impaired by the loss of the teeth, the dentures should restore these by providing a substitute for the lost tissues concerned in the sound production, and they should impose no impediment to the proper exercise of these functions. They should restore the lost portions of the apparatus by which the expressive movements of the face are produced, and not interfere with the normal operation of these activities; and finally, they should restore the facial contours and the fixed expression of the face, and provide such substitutes for the missing tissues in those portions of the mouth which are exposed to view in laughter or speech, as shall be in harmony and accord with the other features of the face. In addition, they must be constructed with the view of utilizing to the best advantage the materials at command, and in consonance with such sound mechanical principles as will insure the efficiency of the appliance.

To design a denture which shall successfully meet these requirements demands an acquaintance with the normal operation of the impaired functions, a recognition of the alterations which have been produced by the loss of the teeth, and a knowledge of the materials and principles which may be best adapted for the restoration of these functions. Furthermore, the placing of an artificial denture is to be regarded as a rational therapeutic measure, in which the requirements of each individual case are recognized, and the appliance designed and constructed to meet the indications thereof.

Here follows a tabulated list of the ends to be subserved by artificial dentures, together with the factors concerned with promoting these ends:

- I. Food preparation
  - A. Stability of the plate.
    - 1. Physical means of retention.
    - 2. Correct plate outline.
    - 3. Correct articulation of teeth.
  - B. Functional efficiency of the teeth.
    - 1. Form.
    - 2. Arrangement.
  - C. Mechanical efficiency of plate and teeth.
    - 1. Strength of teeth.
    - 2. Strength of base-plate.
    - 3. Correct relation of teeth to base-plate to resist stress.
- II. Voice and speech
  - A. Form, position and arrangement of teeth.
  - B. Form and lingual contours of plate.
- III. Expressive movements of face.
  - A. Positions of the teeth.
  - B. Form and labial contours of the plate.
  - C. Relation established between the jaws.
- IV. Facial expression.
  - A. Facial contours.
    - 1. Lips.
    - 2. Cheeks.
    - 3. Relation between jaws.
      - *a.* Positions of teeth.
      - *b.* Buccal and labial contours of the plate.
  - B. Teeth as features of the face.
    - 1. Color.
    - 2. Form.
    - 3. Relative positions.
    - 4. Gums.

These factors will be discussed in detail from the standpoint of the principles underlying their correct adaptation to the individual case.

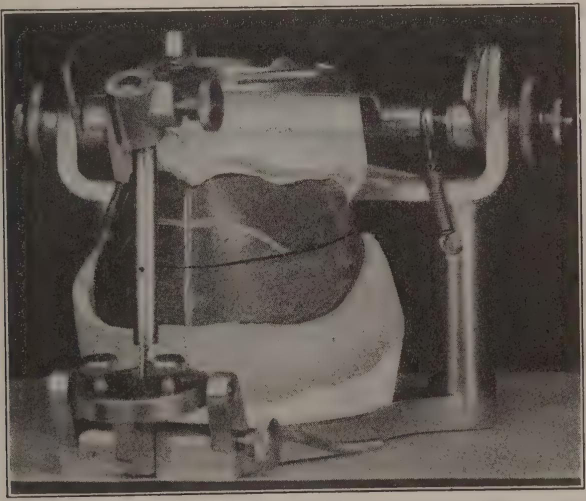

Fig. 143.—Casts arranged upon articulator, with bite-plates.

They will, however, be considered under headings somewhat different from the above, since many of these factors are concerned with both the utilitarian and cosmetic purposes of the plate, and besides avoiding unnecessary repetition, the method selected seems to afford the simplest means of elucidating the subject.

The design of artificial dentures to effect the various purposes above outlined, includes the selection, arrangement, and articulation of the teeth, and the arrangement of the plate form and contours. The technic of denture construction using the various bases will be described in succeeding chapters.

Many of the data which are to be used in the process have been obtained from the patient at the time the bite is taken, and it is supposed that the casts have been mounted properly upon the articulator, and that the bite-plates have been laid aside for reference (Fig. 143).

THE SELECTION OF ARTIFICIAL TEETH.

The considerations which determine the choice in the selection of artificial teeth for a given case are: (1) Anatomical, that they shall have the appearance required of substitutes for the natural teeth, and the form demanded by their proposed functional activities; (2) mechanical, that they may be adapted to the base upon which they are to be mounted, and satisfy such other mechanical demands as are incident to the shape and relation of the jaws in the individual case.

1. **The Size and Form of the Teeth.**—In the selection of teeth for an edentulous case, it is desirable to know the size and shape of the lost natural teeth for which substitutes are required. This is seldom possible, except in the few cases in which the prosthetist has available the extracted natural organs, in which event they should be carefully preserved for guidance in the selection of the artificial teeth. In general, other means must be used for determining the size and shape of the artificial teeth.

Because of the resorption of the alveolar process and the consequent diminution in the size of the maxillæ, but twenty-eight teeth are used for full artificial dentures, the third molars being omitted. If the full complement of teeth were used, they would either be too small, or if of proper size, could not be correctly arranged in relation to the process. The data which indicate the combined width of the teeth must be obtained from the casts of the mouth. When placed in trial upon the upper cast in that relation to the alveolar ridge which it is proposed they shall occupy, with the centrals on either side of the median line, the distal side of the second molar should rest upon the center of the maxillary tuberosity (Fig. 144). In cases of extreme resorption of the alveolar ridge, the cast alone does not furnish all the desired information, but for the most part it is usual to judge of the width of the teeth by their relation to the length of the upper alveolar ridge.

As obtained in full sets from the manufacturers, the sizes of the individual teeth of a series are intended to be correctly proportioned. The "fronts," or six anterior teeth, and the "backs" are matched to have the same general proportion and may be fairly trusted for this.

Cases sometimes present, however, for which the size of the "backs" may be increased to advantage, because the canine of the series comes only to about the position of the canine eminence, while the backs do not reach the tuberosity. The width of the six anterior teeth suitable for a case may easily be determined, except in cases of extreme resorption, by marking the positions of the two canine teeth upon the bite-plate in the patient's mouth, and measuring the distance between these marks with a flexible ruler. The corner of the mouth is usually in relation with the distal angle of the upper canine tooth. Minor differences in the proportion of the back teeth met with in the natural series need not be imitated. Variations in the proportionate size of the six anterior teeth may, however, be imitated to great advantage, and the selection of larger centrals or canines for use in appropriate cases will often be attended with happy results. This will be mentioned in the next chapter.

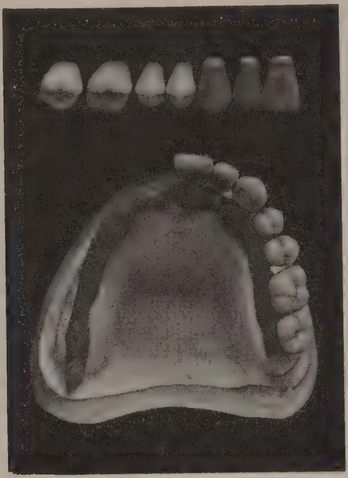

FIG. 144.—Full upper case, showing the trial of artificial teeth of proper size with second molar reaching center of the maxillary tuberosity.

Having decided upon the proper width for the upper teeth, their length is next to be determined, and this is largely decided by the particular type which is considered suitable for the patient, together with a purely physical factor, namely, the position of the high lip line. This latter landmark, it will be remembered, indicates the highest point to which the lip is elevated in smiling and laughter, and it is desirable to have the portion of the artificial denture which is displayed by these acts represented by teeth, unless this would make them too long. However, the correct proportion between the length of the teeth and their already determined width must be preserved in accord with the typal form chosen, and in no case should this consideration be sacrificed. The mobility of the upper lip varies in individuals and in some it may be elevated so high as to display a good deal of the adjoining gum and process. Therefore, this space cannot always be filled in with the artificial teeth, and in cases of a very high lip line, the use of gum-section teeth is sometimes justifiable, or in some cases, teeth with a long ridge lap may prove satisfactory. The distance between the high lip line and the lower edge of the bite-plate, which corresponds to the proposed position of the cutting edges of the anterior teeth, should be the trial length of the artificial teeth, the correct proportioning of this length to the width in accordance with the typal indication of the patient should be the final deciding factor as to this dimension.

The general form of the teeth is, of course, determined by their width and length, but their appearance is also affected by the character of their outline and their surface. These are matters which are discussed in Chapter VIII, so no further reference need be made here.

2. **The Color of the Teeth.**—The most difficult physical characteristic of the artificial teeth to determine is their color. In edentulous cases, as has already been indicated, this must be selected upon a judgment based upon other physical characteristics of the patient. A few remarks upon the color of the natural teeth may not be out of place.

The color of teeth is, in general, due to two things—the intrinsic color of the enamel and dentin, and their proportion and distribution in a given tooth and the light reactions of the tooth structure. Teeth that are opaque may have the same intrinsic color as those which are translucent, but they appear lighter. A tooth in the shadow of the upper lip looks darker than one not shaded. The intrinsic color of the enamel and dentin is in accord with that of the other pigmented tissues of the body. It harmonizes with the color of the hair, the eyes, and in particular with the color of the skin. This latter is of the greatest importance in determining the color of teeth. Ivy[1] has said that the complexion is of great importance in deciding the color of artificial teeth. Joseph Head[2] has stated his belief that the fundamental color of the skin over parts of the body protected from the sun, and that of the teeth is the same, and that if the pink element in the former due to the presence of the blood is removed by pressure upon the part, the color of the skin thus observed should be the fundamental color of the artificial teeth. The author is not wholly prepared to accept this view, but has observed instances in which it was fairly accurate.

The state of organization of the teeth has been supposed to partly account for the color. It is certain that the greater translucency of the enamel in certain types of teeth is a result of its high state of organization, and accounts in part for the blue cutting edge characteristic of these teeth, while the opaque enamel of other types is commonly observed to be of poorer structure.

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[1] American System of Dentistry, vol. 2, p. 1034.

[2] In private conversation.

The proportion between the enamel and dentin also is related to the color of the teeth. In some types of teeth, for instance, the opacity of the enamel and the fact that it is generously backed up with dentin partly account for their color, while in the thin teeth, the enamel plates at the cutting edges of the incisors enclose little or no dentin, permit the light to be carried through, and they appear blue at this point. Furthermore, the commonly observed yellow color at the neck of incisor teeth is due to the thinness of the enamel, which permits the yellow color characteristic of dentin to show through.

As age advances, there is a deepening in the shade of the tooth, which is due to a molecular change in its tissues, and teeth are a shade or so darker in middle or late life than they were in early years.

The fact has been brought out by E. A. Royce,[1] after a careful examination of a large number of natural teeth, that the individual members of any given natural set vary much in shade. He says, "In our study of this subject we must have some standard by which to measure the shade of each tooth, and for this standard the upper central incisors of the denture under consideration were always taken. Some means being necessary to convey to you the different shades of the teeth in the mouth, I selected 0, or zero, to represent the shade of the central incisors, using numerals to express the other shades—the higher the numeral the darker being the shade." . . . "The upper central incisors are the lightest, the laterals are darker, and the canines are darker still. The first bicuspids are generally lighter than the canines, and the second bicuspids lighter than the first. The first molars generally vary but a shade or so from the second bicuspids."

We next come to discuss the selection of teeth in order that they may fulfil the mechanical requirements imposed by the base used, the relation of the jaws, and the amount of resorption of the process.

3. **The Base.**—Artificial teeth are constructed with a means of attachment and a general form suitable to the base upon which they are to be mounted. Teeth for vulcanite work are equipped with two headed pins, or are provided with an undercut recess into which the vulcanite extends and securely locks them to the base-plate. Plate teeth are suitable for crown and bridge or metal plate work. In England and on the Continent they are used to some extent for vulcanite work, for which purpose they are made with long pins which are bent into a hook for attachment to the base. For cast dentures, where the metal is cast directly about the teeth, vulcanite teeth are used and they are occasionally useful in continuous-gum dentures, although the teeth made especially for this work are the usual indication.

4. **The Amount of Resorption of the Alveolar Process and the Distance Between Jaws and their Relation.**—In the mounting of the artificial

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[1] The Dental Review, vol. **15**, pp. 301, 934.

teeth, other things being equal, it is desirable to have their occlusal ends occupy the position with relation to the alveolar ridge which was characteristic of their natural predecessors. The incisors, canines, bicuspids, and molars should be placed, therefore, over the alveolar ridge in the upper jaw, and slightly to its buccal and labial sides (Figs. 145 and 146). In the lower jaw the incisors and canines should be slightly to the labial side and over the ridge, while the line of teeth then crosses the ridge, the last molars being somewhat to the lingual side of its summit. This ideal method of placing is by no means always possible, because of the state of resorption of the process and the relation of the jaws. The proper placing of the teeth will be discussed later in this chapter, but inasmuch as they may be selected of such form as to greatly facilitate this, the mechanical demands upon them must be known at the time they are selected, and the choice made to further this end. There are also mechanical requirements incident to the strain upon the tooth in use, which may be furthered by judicious selection.

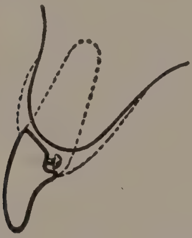

Fig. 145. — Diagram showing the ideal relation of an artificial incisor to the alveolar process.

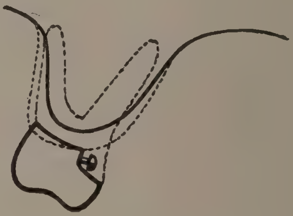

Fig. 146.—Diagram showing the ideal relation of an artificial molar to the alveolar process.

The labial surface of the fronts and the buccal and occlusal surfaces of the backs are fashioned to meet anatomical demands; other portions of the teeth are designed to meet the mechanical demands above referred to. As plain plate teeth are the ones in which this provision is best brought out, they will be used to illustrate the principles.

The anterior teeth have the headed pin which affords attachment to the base-plate, a pin guard, which makes the division between "the bite" and "the shut," and also what is technically called "the ridge lap." Other things being equal, it is desirable in full sets to have the pins near the alveolar ridge. The "ridge lap" is intended to be in relation with the alveolar ridge, and "the bite" makes up the other part of the length of the tooth. Long bite teeth, it must be remembered, are not the strongest type of teeth because of the leverage upon them, the pin being the fulcrum, the length of "the bite" part of the tooth representing the power arm. Long bite teeth are, therefore, not recommended for use in cases demanding great strength in which other types will answer the requirement. In most full cases, however, they may be used with reasonable assurance of sufficient strength.

The upper bite-plate having been removed, the space between the anterior edge of the lower bite-plate and the alveolar ridge is to be filled in with "the bite" of the teeth selected, the remainder of the length of the tooth has to be made up in ridge lap (Fig. 147). Thus when there has been little resorption of the process and the jaws are some distance apart, the teeth may rest almost upon the ridge, and a tooth with a short ridge lap is selected (Fig. 148). Where the jaws are close together, however, a tooth with long ridge lap must be used, and, of course, of short bite, since in teeth of a given length the ridge lap and bite are usually inversely related (Fig. 149). Where there has been much resorption of the process and the teeth are to be mounted almost upon the ridge, a short ridge lap is indicated (Fig. 150). To avoid the use of a long bite tooth in a given case, a tooth with a long shut may be used, but it must be remembered that the plate must not be made too thick at the portions about the pins, as it may interfere with speech (Fig. 151).

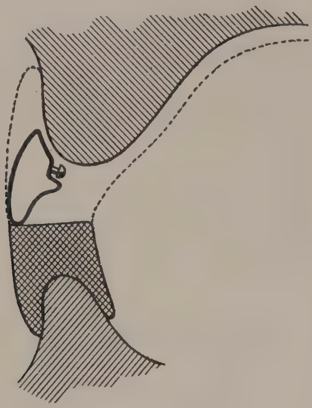

FIG. 147.—Diagrammatic drawing showing section through upper cast and lower bite-plate, with artificial incisors properly filling in the space. The dotted line indicates the contour of the upper bite-plate.

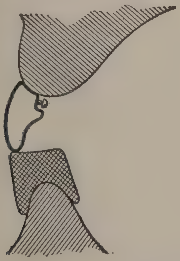

FIG. 148.—Use of short ridge lap with small amount of resorption of process.

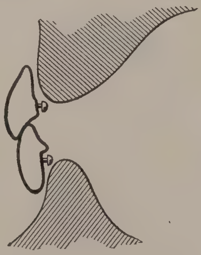

FIG. 149.—Use of long ridge lap with a short distance between the jaws.

Where plain teeth are to be mounted directly upon the gum, as in all temporary dentures, a short ridge lap must be used.

When the antero-posterior relation of the jaws is abnormal, as in protruding upper or lower jaw, this condition may be accommodated in the teeth selected. Thus, in a protruding upper jaw, a short ridge lap is indicated for the upper teeth, while in a protruding lower jaw, teeth with a long ridge lap may be used advantageously in most instances (Fig. 152). In a protruding upper jaw, too, the use of teeth with a flat face provides a means of making the protusion less apparent, while on the other hand, when the lower jaw is anteriorly placed, so-called "bow-faced" teeth will lessen the apparent protrusion of the lower jaw and often permit a better arrangement of the upper and lower incisors (Fig. 153).

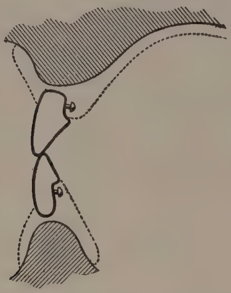

Fig. 150.—Use of short ridge lap tooth with much resorption of process, mounting tooth directly over ridge.

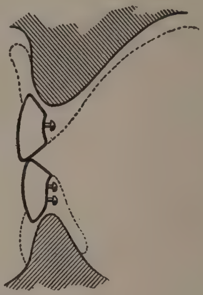

Fig. 151.—Use of long shut tooth, with short ridge lap, where there is much space between jaws and little resorption of the process.

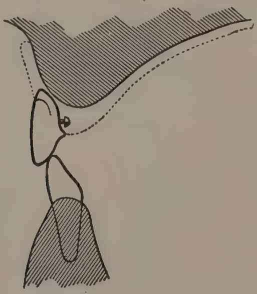

Fig. 152.—Use of flat-faced tooth for protruding upper jaw.

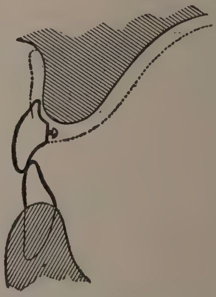

Fig. 153.—Use of bow-faced tooth for protruding lower jaw.

In the bicuspid and molar region, the adjustment of these teeth to the alveolar ridge may be made with greater ease. The use of teeth as long as the distance between the ridges will permit of their proper placement, is indicated. This brings the tooth closely in relation with the ridge, thereby lessening the amount of base used, and, if the amount of the tooth above the pins is as great as possible, this is an added advantage, for the bulk of the porcelain is an element of strength (Fig. 154). Cases will be met with, however, where the distance between the two alveolar ridges is so short that recourse must be had to so-called "saddle back" teeth, although this is more especially necessary in partial dentures (Fig. 155).

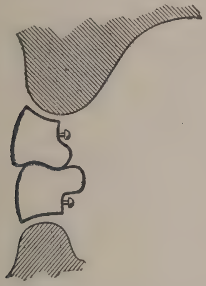

Fig. 154.—Fitting of molar teeth; filling in space between the ridges.

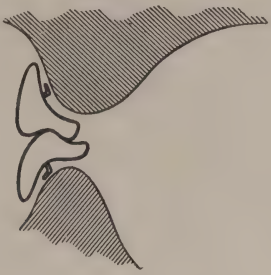

Fig. 155.—Use of saddle-back teeth in case with short distance between ridges.

The use of Park pinless teeth is only possible when the distance between the jaws is sufficient to permit them to be placed almost directly over the ridge, in which instances their anatomical form will be found advantageous. Plate teeth and continuous-gum teeth do not have the divisions of vulcanite teeth above alluded to, except that in the case of the former a general conformation to this plan is made by grinding at the time they are fitted, and they should be selected with this in view.

The use of gum-section teeth is the indication in some cases, but the number of these instances is small. The fixed relation between the teeth of a block limits their usefulness because there is little or no latitude in their arrangement. They are contraindicated in those cases in which little resorption of the alveolar ridge has taken place for the obvious reason that they would cause too great fulness of the denture at this place. They are used to best advantage in cases in which much of the denture is displayed in laughing, as indicated by the high lip line, when the space between it and the lower bite-plate cannot be filled in with a plain tooth without the use of one anatomically too long. They, of course, should be selected as regards their anatomical and mechanical forms by the same indications as prevail with plain teeth. The natural appearance of the gum portion of the section, an imitation of mucous membrane only equalled by that of continuous-gum work, is the only advantage which they possess.

I. THE ARTICULATION OF THE TEETH.

The Arrangement of the Anterior Teeth.—The objects to be subserved in the placement of the anterior teeth are those of incision, of articulate speech, the establishment of correct facial profile and contours by their support of the lips and cheeks, and finally, the securing of their harmonious relationship as a feature of the face. As the appearance of the patient is chiefly affected by the upper anterior teeth, and as these may be arranged first, and the distal teeth subsequently placed to accord and properly functionate with them, it is usual to arrange them first. It is supposed that the casts have been mounted upon an articulator capable of individualizing the movements of the mandible, and that the bite-plates have been retained for the data which they furnish in the setting of the teeth.

The requirements imposed upon the anterior teeth by their functional relations in the operation of incision are so closely related to the subject of plate maintenance that they may be considered subsequently when this matter is dealt with. Suffice it here to say that the utilitarian and cosmetic purposes of the denture are often in conflict in the arrangement of these teeth. For the most part it is desirable to consider as of first importance the requirements of appearance, and then to make such compromise between these demands and those imposed by the incisive function as will subsequently be pointed out as advisable. In the case of patients well past middle life, where the resorption of the alveolar process complicates the placing of the anterior teeth in such a way as to serve both the ends of appearance and those of function, it is wise to sacrifice the former in favor of the latter, because in these instances the correct functioning of the appliance is of the greater importance.

The anterior teeth are the chief ones concerned in the functional relations of articulate speech, but it is commonly true that when their positions satisfactorily answer the other necessary requirements, they usually meet the demands of speech because of the ability of the tongue to adjust itself to various conditions. The function of speech is also largely influenced by the form and contours of the plate, and these several considerations will be discussed later.

The part played by the anterior teeth in the support of the lips in proper profile and contour will also be discussed under a subsequent heading.

It is here purposed to take up, first, considerations relative to the appearance of the anterior teeth as a feature of the face. In order to serve as a feature of the face which thoroughly harmonizes with its environment, it may be said, in general, that the anterior teeth should answer the requirements imposed by form and color relationships, and should also accord with the age indications of the case. Inasmuch as the data are lacking which would permit an exact reproduction of the appearance of the natural teeth, the object sought should be to have the artificial teeth appear as a natural endowment of the individual, and exhibit evidences of the changes which would have been present upon the natural teeth at the age of the individual. In addition to these requirements, their appearance must possess an intrinsic artistic value. It would not be enough, for instance, to exactly reproduce in the mouth of a patient the characteristics of the natural teeth of another individual, selected at random, though of similar age and type. Such a denture would be natural looking, but it might not also be pleasing to the eye. Natural dentures to be copied should have some artistic value, since in the mouth of an edentulous patient a denture may be placed which accords with the age and other indications and also has intrinsic artistic worth.

In the arrangement of the artificial teeth, the purpose is to imitate the original endowment of the individual and to imitate the effects produced by the causes which have operated in the environment of the teeth, and these effects must be copied from the observed effects existing in mouths under similar conditions. We shall now take up in detail the factors which contributed to these several ends. The articulated casts and the bite-plates furnish the data for the following items: The inclination of the teeth, the median line, the position of the cutting edges of the teeth, the curve of the arch, the support of the lips, and the antero-posterior relation of the jaws.

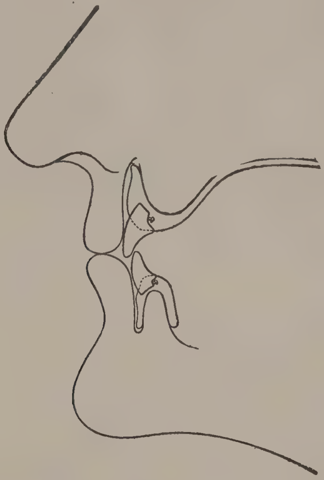

FIG. 156.—Drawing showing ideal relation of artificial teeth to the lips.

1. **The Relation to the Lips.**—The proper relation of the teeth to the lips largely contributes to the beauty of the teeth as a feature of the face. The most beautiful cases are those in which the cutting edges of the upper anterior teeth project but very slightly below the lower margin of the upper lip (Fig. 156). In some cases the natural teeth have been so much abraded, or are so situated that they do not reach the margin of the lip, while in other instances their edges extend much below this line. In most edentulous cases it is advisable to establish the teeth in the first of these relationships (Fig. 157). With this end

in view, the occlusal surface of the upper bite-plate has been trimmed to a distance $\frac{1}{16}$ inch below the lower margin of the upper lip and represents, therefore, the position of the cutting edges of the anterior teeth. The general line of cutting edges is also parallel with the line of separation between the lips, a datum likewise furnished from the bite-plate.

In the setting up of the teeth, the upper plate should be removed and laid aside for reference. The correct distance between the casts is maintained by the incisal guide rod.

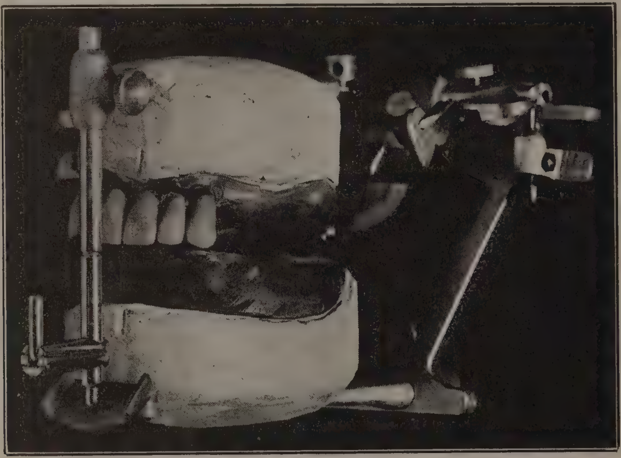

FIG. 157.—Six upper anterior teeth in position and in proper relation with lower bite-plate. Side view.

2. **The Median Line.**—The median line of the mouth having been marked on the casts, determines the position of the division between the upper central incisors which are the first teeth to be put in place. Their cutting edges should be in relation with the outer edge of the occlusal surface of the lower bite-plate.

3. **Inclination to the Ridge.**—The inclination of the long axes of the teeth to the alveolar ridge has been largely determined by the lower portions of the labial surface of the bite-plate. These portions of the bite-plate were made to support the lips properly, and the anterior teeth must be so placed that their labial surfaces occupy the position of the labial surface of the bite-plate.

The teeth support and give form to the lip, but in addition, their inclination to the ridge affects their appearance. This must be sometimes made to accord with the demands imposed by the functional purposes of the denture. After the anterior teeth have been set up, their inclination should accord with that observed for teeth of similar shape in jaws similarly related.

The teeth of a normal or ideal denture in jaws having a correct antero-posterior relation are inclined about as follows: The long axes of all of the anterior teeth are inclined slightly outward from a vertical plane, the angle made with the vertical varying from a slight divergence to a considerable amount. The long axes of the central incisors slightly diverge from the sagittal plane of the body. Those of the laterals, diverge slightly more, while those of the canines are more nearly vertically located. Where the lower jaw is distally related to the upper, the upper teeth often incline slightly backward, while where the lower jaw is protruding, the upper anterior teeth are usually inclined outward, the lower teeth having a lingual inclination from the pressure of the lips.

4. **The Curve of the Arch.**—The arch formed by the cutting edges of the anterior teeth should be in accord with the curve of the bite-rim, which has been shaped in accord with the arch of the alveolar process and the face form of the patient.

5. **The Relative Position of the Teeth.**—In the ideal or typical natural denture, the anterior teeth occupy definite relative positions. Their cutting edges are arranged in the arc of a circle and they are placed regularly and symmetrically. This condition obtains, however, in Nature in a comparatively small proportion of cases, an irregular alignment or a dissimilarity between the two sides of the arch being the rule rather than the exception. In the arrangement of the anterior artificial teeth, due cognizance should be taken of this state of affairs. In the effort to make an irregular alignment assume a natural appearance, the relationship which exists in natural dentures between the alignment of the teeth and the form of the arch itself should be recognized. It would be manifestly out of place to arrange the teeth irregularly for a patient of a type in which the arrangement is commonly regular. Furthermore, any irregularity imitated should be that which observation has shown to be associated with the teeth and type of such cases. It should also be borne in mind that age has an influence in the production of irregularities of the anterior teeth through causes which operate subsequent to the original positioning of the teeth. Attention should be given to the association between the irregularities imitated and the antero-posterior relation of the jaws, and in all instances the general relation between cause and effect should be borne in mind, and results established to accord with probable operating causes.

The regular alignment of the natural teeth has been described. This is to be established with artificial teeth in mouths of patients for whom it is suitable. It should be reproduced for younger patients and those in whose mouths regularity of the teeth would be in accord with regular and symmetrical features of the face. On the other hand, irregularities of the teeth are to be imitated in the mouths of young patients of the nervous temperament, since the natural teeth in these mouths are frequently irregularly aligned.

The irregularities of the anterior teeth commonly observed are those with the long axis of the tooth departing from its position in the ideal form of the denture, and irregular positions of the occlusal edges of the teeth.

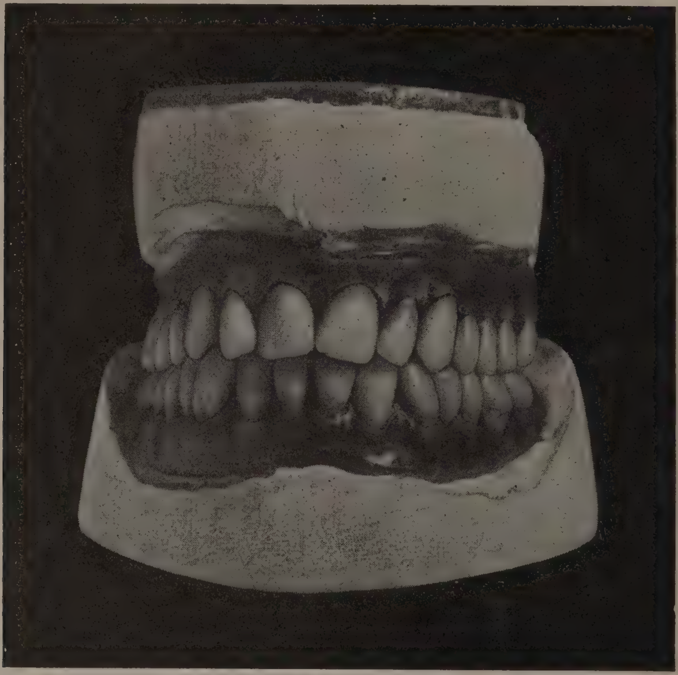

FIG. 158.

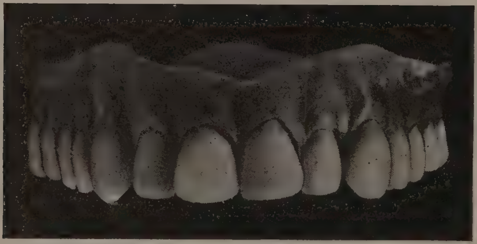

FIG. 159.

FIGS. 158 and 159.—Dentures showing irregular position of the anterior teeth.

The following may be advantageously imitated in appropriate cases (Fig. 158 and 159):

1. Rotation of the central incisors with their distal surfaces labially placed.
2. Rotation of centrals with their distal surfaces lingually placed.

3. One central overlapping the other with laterals overlapping.
4. Elongated centrals.
5. Overlapping laterals.
6. Alteration in position of the long axes of the teeth.
7. Centrals slightly lingually inclined.

The lower teeth are irregularly placed frequently as follows:

1. Centrals with the distal surfaces turned outward.
2. Rotation of the lateral incisors.
3. Overlapping of laterals or centrals.
4. Overlapping of one or both canines.

Spaces do not exist between the teeth of a natural denture without some abnormal operating cause. Their existence is usually a defect in the beauty of the denture, and the imitation of this in artificial teeth is seldom justifiable, unless it be in imitation of a condition known to have existed in the mouth of the patient.

6. **The State of Wear of the Teeth.**—One of the defects commonly observed in artificial dentures is that the teeth are inserted without an alteration of their occlusal surfaces to imitate that produced by the wearing of the teeth from use. In Chapter I, the question of the wearing of the teeth was considered at some length. Artificial teeth should be made to accord with the probable state of wear of the teeth of the patient. The wear on the teeth in a natural denture is determined partly by the form of the teeth and the manner of movement of the mandible peculiar to the individual. While not directly related to the age, it must be, in some measure, in accord with it, or the length of service which the denture has seen.

It is seldom advisable to imitate greater degrees of wear than the second, as further wearing is of seldom occurrence under the conditions of modern civilization and is infrequently observed in the natural teeth.

It is seldom the case that an artificial denture is required in a patient so young that, had the natural teeth remained, no evidences of wear would have existed. In any but the youngest patients the cutting edges of the incisors should be ground with a corundum wheel to portray this evidence of their use, and the amount of wear should be graduated from a slight alteration of the cutting edges to that observed in the second degree of wear in which the dentin is exposed. What may be considered typal cases are illustrated in Figs. 160, 161, and in the imitation of this condition the relation of cause and effect, as above alluded to, must be constantly borne in mind. To illustrate in detail one case which may be taken as a fair sample, Fig. 160, presents the conditions which might reasonably exist in a natural denture of a patient about thirty-five years of age. The forward movement of the lower jaw has caused the wearing of the upper incisors into slight depression where they were in contact with the lower teeth. The lower teeth have similarly worn. Fig. 160, shows a case in which there has been considerable over-bite of the incisors, where the upper teeth have been worn at the expense of the lingual plate of the enamel, the lower teeth at the expense of the labial. Fig. 161 shows a case of the second degree of wear which might be found in the mouth of a patient aged fifty years, where the cusps have worn down sufficiently to permit the mandible to move forward, producing an edge-to-edge bite, with

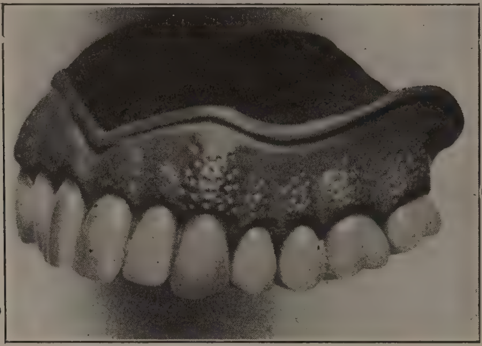

Fig. 160.—Denture showing imitation of first degree of wear.

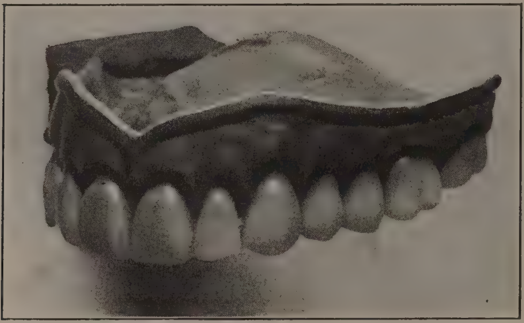

Fig. 161.—Denture showing imitation of second degree of wear.

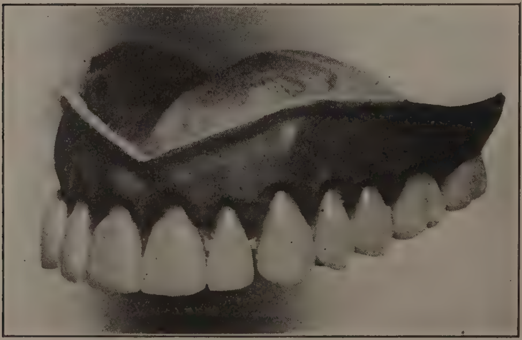

Fig. 162.—Denture showing imitation of recession of the gums.

the complete obliteration of the occlusal ends of the teeth, the exposure of the dentin, and a slight chipping of the enamel. Other typical cases of wear in natural dentures may be observed by the dentist and imitated in a similar manner.

7. **Recession of the Gums.**—This condition, when of a physiological nature, is seldom observed in the mouths of patients younger than thirty-five years of age, although it is progressive by almost imperceptible degrees up to this time. Pathological recession of the gums, attended with an exposure of the cementum and a thickening of the gingival margin, with a disappearance of the gum occupying the interproximal space, is frequently seen in these patients at a later period in life and may be imitated to advantage in such cases (Fig. 162).

When it is desired to imitate a considerable recession of the gums, the use of Park "pinless teeth" may prove advantageous. These teeth have the full lingual contours of natural tooth crowns, and in addition, a section of the root is reproduced. It is possible therefore, to expose these root portions by suitable carving of the vulcanite, in imitation of natural conditions of recession.

8. **Individual Peculiarities.**—Defects in the teeth of a denture, which have assumed the form of an individual peculiarity, are often to be reproduced in the mouths of patients in which they are known to have existed. The defects are those of form or structure. In the mouths of patients of the nervous temperament with delicately shaped teeth, filling operations have usually been necessary before the time at which an artificial denture is required, and in such cases, the insertion of fillings in the anterior teeth is a measure which frequently adds to the natural appearance of the denture.

Where a prominent gold filling has existed in a natural tooth, it may be reproduced in the artificial, and will tend to preserve the identity of the individual, in which cases it is the indication.

The lateral incisors are usually the first anterior teeth requiring filling operations, and in those cases in which fillings are inserted for purposes of naturalness, and without a history of their former existence, these teeth should be selected to receive them. In the insertion of the filling regard should be paid to its placement in a position in which carious cavities commonly occur. A gold filling on the mesial surface of either or both lateral incisors or upon the mesial or distal surfaces of either central incisor will answer these several requirements, and in all cases the relation of cause and effect, the latter represented by the filling, should be borne in mind.

Discoloration of the teeth is another condition to be imitated to advantage in selected cases. One condition to be imitated is the staining of the cervical third of the labial surface of the crowns, a yellow discoloration being sometimes found in these portions of the natural teeth. The imitation of an eroded area in this location by grinding the surface which is then stained yellow, and the staining of the occlusal surfaces of the teeth to imitate the discoloration of the dentin observed in the mouth of users of tobacco, is the one most commonly of service.

The imitation of the discoloration incident to devitalization of a tooth may be some times justifiable, but rarely except in those cases in which a similar condition was known to exist.

The opaque white spots on the surface of the incisors, indicative of an error in the development of the enamel, is also a condition which may be reproduced. The indication for this, however, seldom presents itself, and it is only really necessary for partial dentures in which an artificial tooth is to be made to match natural teeth exhibiting this condition.

The reader is referred to Chapter VIII for a more extended discussion of the esthetic considerations relating to artificial teeth.

THE ARTICULATION OF THE BISCUPID AND MOLAR TEETH.

When all is said about the purposes of artificial dentures, it will be seen that their chief function is the repair of the apparatus by which mastication is accomplished. The molar and bicuspid teeth are paramount factors in the accomplishment of this object. Their form and arrangement should be determined largely by considerations relative to this purpose. They also contribute by their arrangement to the general object of plate maintenance. The correct placing and form to be given them to promote these purposes will now be considered.

A knowledge of the form and functional relations of the natural teeth will be of great assistance in the articulation of the artificial bicuspids and molars. While it is not possible or desirable to exactly reproduce in the artificial teeth the form and arrangement of the natural, because of essential differences in the conditions attending their use, much may be learned from a study of the normal operation of mastication in a typal or ideal natural denture. As placed in the mouth, the natural teeth are firmly imbedded in the alveolar process, and during their use for purposes of mastication, stress may be applied to them in a variety of directions. On the other hand, artificial teeth are mounted upon a base supported upon the mucous membrane, and they must be so formed and located that not only is the stress which is exerted upon them in the crushing of the food to be so arranged as to be best resisted by the tissues supporting the plate, but that stress must be so disposed as to hold the dentures firmly upon their base instead of causing them to be displaced. These essential differences, therefore, exist between natural and artificial dentures and the principles utilized in the former must be modified and adapted to promote the best interests of the latter.

Two objects are, therefore, held in view in the articulation of artificial teeth: (1) To have the teeth shaped and located so that they may be brought into effective functional relations during the movement of the mandible; (2) to so arrange them that the stress brought upon them during their use in mastication will serve to maintain the dentures upon their support and not to displace them. How may this be accomplished?

Let us next direct attention to several characteristics of an ideal natural denture which have to do with the function of mastication. In the ideal denture there is a definite relation between the form of the occlusal surfaces of the teeth and the path which the condyle pursues, and in consequence, with the movements of which the mandible is capable. It has been shown in Chapter I how this relationship renders the denture a more effective masticating apparatus. This principle is to be applied to artificial teeth; for while it is rarely the case that in a natural denture the teeth absolutely follow the typal design for the apparatus, in the artificial denture the forms and positions of the teeth are under control and may be determined and coördinated with the mandibular movements.

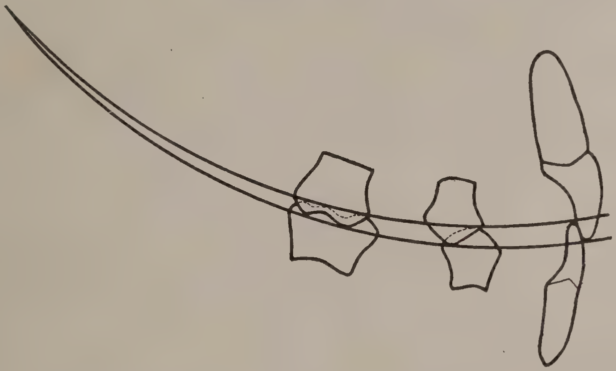

Fig. 163.—Diagram showing typal proportion between cusp length overbite and compensating curve. Modified from Bonwill.

It will be remembered that in the typical natural denture the so-called "compensating curve" of the bicuspid and molar teeth is directly correlated with the path pursued by the condyle in its forward excursion (Fig. 163). This provides for a sliding contact between the two series, upper and lower, in the forward movements of the mandible until its anterior end is depressed by the sliding of the lower incisors upon the lingual surfaces of the upper. The curved plane of occlusion, or as it is frequently called, "the compensating curve," is a continuation of, or is concentric with, the path pursued by the condyle. This correlation is to be established by the form and arrangement of the artificial teeth to subserve a similar end.

It will also be remembered that the buccal cusps of both upper and lower series are placed at a progressively higher level from the first bicuspid to the last molar. Also that the buccal cusps of the lower and the lingual cusps of the upper are the larger of the lines of cusps.

This permits a sliding contact between the teeth in the lateral excursion of the jaw. When the mandible is moved to the right side for instance, the high buccal cusps of the lower series on the right side slide upon and come in contact with the short buccal cusps of the upper, the large lingual cusps of the upper being at this time in contact with the lingual cusps of the lower series (Fig. 164). On the side opposite to that from which the movement has taken place, the high buccal cusps of the lower have moved upon the large lingual cusps of the upper, the descent of the condyle on this side making it necessary that two long cusps be in relation to preserve the contact. When the mandible is brought back to the position of the resting bite, the sliding contact is maintained. A correspondingly similar relation of the teeth exists when it is carried to the left side. This characteristic of the ideal natural denture is also to be reproduced in the artificial.

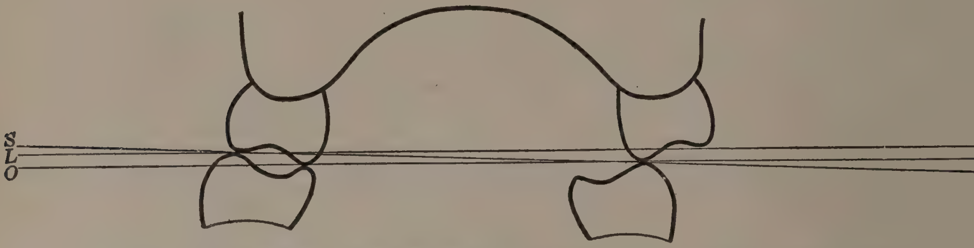

FIG. 164.—Diagram illustrating contact of cusps in lateral excursion of the mandible. Section through jaws at position of second molar. O P, line touching lingual cusps of upper molars; L R, line touching buccal cusps of upper molars; S T, line touching buccal cusps of lower molars, showing the downward movement of the mandible on the right side necessary for contact of the cusps.

In the natural denture, when the mandible is protruded in incision to bring the occlusal edges of the incisors into contact, there is no contact between the distal teeth of the two series. In the artificial denture the over-bite of the upper incisors is to be made less than its natural prototype, so that when the mandible is protruded for incision and the incisors are in edge-to-edge relation, contact between the last molars of the series is to exist at the same time. It will be seen that this arrangement of the forms and positions of the artificial teeth provides for a simultaneous contact between the series of the two sides during the lateral movement of the mandible in mastication. This serves to maintain both upper and lower plate dentures in place by pressing them firmly upon the tissues which give them support. During the use of artificial dentures for mastication this provision greatly contributes to their maintenance. It does not, of course, provide against displacing stresses occurring in mastication before the two series have come into contact, and during the passage of the cusps through the food until those of the two series touch; but in the retraction of the jaw from this point to the position of the resting bite, during which time the chief crushing of the food takes place, the teeth preserve a sliding contact which tends to keep the dentures in place. This arrangement of the teeth also assists in the maintenance of the dentures during the operation of incision, for as soon as the incisors have met through the food that is being incised, the distal teeth are in contact, and as the mandible is retracted to the position of occlusion, the lower incisors slide upon the upper and the dentures are firmly pressed into place.

From the above paragraphs it will be noted that the arrangement of the teeth to provide for balancing contacts between the two dentures during those mandibular movements in which the two series of teeth touch at any point, is of extreme importance in the maintenance of the dentures. This idea originated with Bonwill and is exemplified in his well known "three-point contact" plan. In this he proposed that if the two series of teeth touched at three widely separated points, that is, at the rear on each side and in the front, during the various mandibular excursions, support would be furnished to each of the dentures, and leverage tending to unseat them would be avoided. While the principle enunciated by him has remained unchanged, present methods of tooth articulation provide for considerably more than three points of simultaneous contact, and for an uninterrupted gliding of the surfaces of one series upon the surfaces of the other during mandibular movements. This is called "balanced" occlusion or articulation of the teeth.

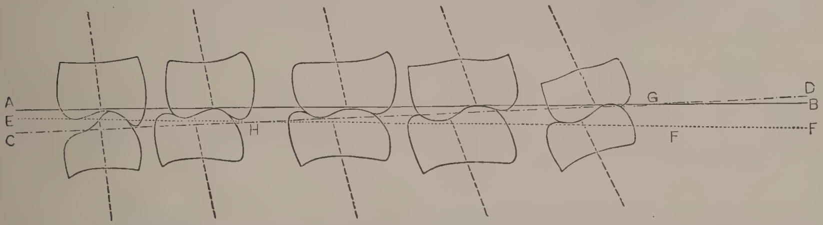

Fig. 165.—Diagrammatic view of the relative height of the buccal and lingual cusps of the molar and bicuspid teeth. (Walker.)

As it is highly important that the prosthetist should have definitely in mind the contact relations which he proposes to establish between the teeth before he begins to arrange them on the articulator, it is desirable that these should now be discussed. It will be well to note that the side toward which the mandibular (or articulator) movement takes place is called "the working side," as it is on this side that the more effective mastication takes place, while the other is called "the balancing side."

Balanced Occlusion.—During lateral movement, on the working side the whole series of buccal cusps of the lower teeth from the canine backward must slide on the walls of the fossæ of the upper teeth, and when they reach the position shown in Fig. 166, that is, when the buccal cusps interdigitate in the edge-to-edge relation, the corresponding lingual cusps of these two rows must likewise be in contact. On the balancing side, the contact varies somewhat according to the plan of balancing that is to be adopted or that can be effected. The Gysi Trubyte teeth are designed to furnish a single balancing point through the use of a second upper molar with a single very long lingual cusp. The balance obtained in this way is shown in Fig. 167, in which this

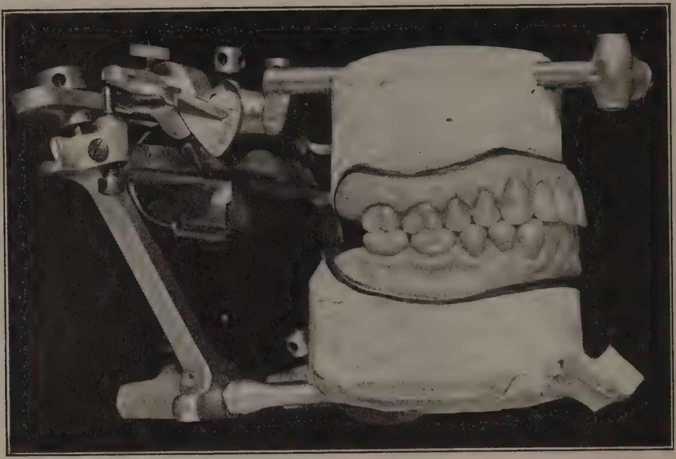

Fig. 166.—Contact relations of the teeth on the working side.

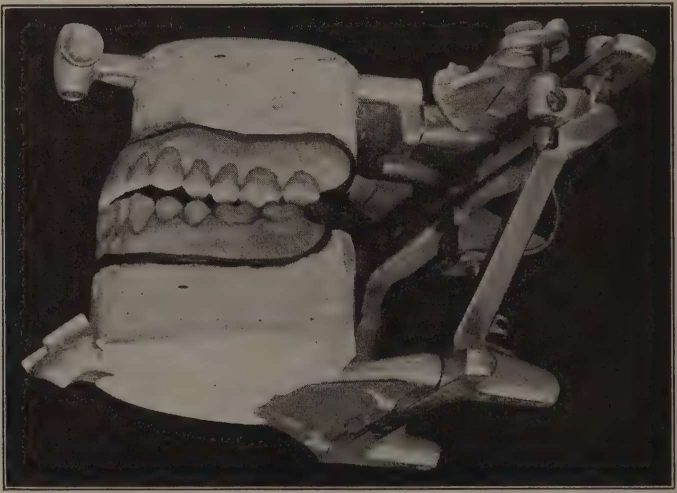

Fig. 167.—Contact relations of the teeth on the balancing side.

cusp is shown in contact with the disto-buccal cusp of the second lower molar. Others prefer to arrange for contact of other cusps on this side, and seek to establish such relations with all the lingual cusps of the lower series. The teeth of some manufacturers are designed to make possible this type of balancing relation.

In the anterior excursion of the mandible (or the articulator) it is essential that, when the incisors are in the edge-to-edge relation, there shall be contact at least at each side in the rear between the second molars. By a suitable adjustment of the over-bite and of the curve of the occlusal plane of the teeth, such sliding contacts may be provided in the forward movement so that, when the incisors are end to end, there is not only contact at the rear but many of the intervening teeth likewise touch.

Factors Governing Positions of Teeth.—In order to effect such an arrangement of the artificial teeth as has been set forth above, it is desirable that the prosthetist should have an intelligent appreciation of the various factors that control the position of the individual teeth, as well as those which determine their general arrangement. He will thus be able to follow the technic with an understanding of the significance of each step recommended, and should be able to correct any errors in his work by a knowledge of what has gone wrong.

In the mechanism of a properly articulated set of artificial teeth, either in the mouth or in the articulator, there are five items which sustain interdependent and reciprocal relationships. These are:

1. *Condylar guidance,* or guidance to movement provided by the condyle paths (both downward and forward as well as lateral).
2. *Incisal guidance,* or guidance furnished by the upper incisors or the incisal guide-rod plane.
3. *Curve of the plane of occlusion* (both laterally and antero-posteriorly).
4. *Height of the cusps of the teeth* (sometimes measured by the reëntrant angle between buccal and lingual cusps).
5. *Plane of orientation* of the dentures.[1]

The relationship borne between these five factors has been well defined by Hanau[2] in what he has called the laws of articulation.

THE TEN MAIN LAWS OF ARTICULATION.

"1. An increase of the inclination of the condylar guidance increases the prominence of the compensating curve.

"2. An increase of the inclination of the condylar guidance increases the inclination of the plane of orientation.

"3. An increase of the inclination of the condylar guidance decreases the inclination of the incisal guidance.

"4. An increase of the inclination of the condylar guidance increases the heights of the cusps, *progressively toward the posterior.*

---

[1] Hanau: Dental Engineering, p. A–44.

[2] Ibid., p. 4.

"5. An increase of the prominence of the compensating curve decreases the inclination of the plane of orientation.

"6. An increase of the prominence of the compensating curve increases the inclination of the incisal guidance.

"7. An increase of the prominence of the compensating curve decreases the heights of the cusps, *progressively toward the posterior.*

"8. An increase of the inclination of the plane of orientation increases the inclination of the incisal guidance.

"9. An increase of the inclination of the plane of orientation decreases the heights of the cusps *equally, or nearly so.*

"10. An increase of the inclination of the incisal guidance increases the heights of the cusps, *progressively toward the anterior.*"

A careful study of this statement of the relationships of these several factors will show that the only one which is definitely fixed by the patient is the condylar guidance (which varies with different patients), and that this is definitely related to each of the other factors, and that they vary in accordance with variations in it. For example, for a marked downward condyle path, the curve of the plane of occlusion must be made to correspond by having greater curvature.

The next point which must be noted is that the plane of orientation of the dentures is definitely determined and recorded in the bite-plates in the preliminary stages of their use, so that this becomes a fixed factor when the stage of setting the teeth has arrived. If the curve of the plane of occlusion has been worked out by grinding the bite-plates in the mouth, as described in Chapter V, or has been formed in the bite-plates upon the articulator by the Wadsworth method later described, this now becomes a fixed factor; so that of the five factors which vary in any given case, three of them are now fixed and only two remain for consideration.

Incisal Guidance.—The function of the incisal guide-rod sliding upon its plane is to impart an opening movement to the articulator as the lower cast is moved forward in imitation of the effect produced by the sliding of the lower incisors upon the lingual surfaces of the upper in both forward and lateral movements. Of course, no data are procurable from the patient which will indicate what this should be. It is extremely desirable that it should be used, as it gives a guide in articulating the distal teeth and prevents the bows of the instrument from coming closer together in these movements. After the teeth have been selected we have introduced another fixed factor of the five having reciprocal relations. Since the teeth available on the market which are well designed to establish articulating relations have a certain narrow range of cusp height (or cuspal angle of 37 to 45 degrees), it is possible to set the inclined plane in accordance with a formula representing the proper relation between these three elements: *i. e.*, condyle slant, incisal guidance and cusp height. This formula as proposed by Hanau[1] is contained in the subjoined table.

---

[1] Hanau: Dental Engineering, p. A–41.

"Condyle indications.	Incisal indications.
Minus 5° and below	35° or more
Minus 5° to plus 20°	25° to 40°
Plus 15° to plus 30°	15° to 30°
Plus 25° to plus 45°	5° to 20°
Plus 40° and above	10° or less"

With both the Hanau and Gysi articulators, the incisal guide plane should be set as soon as the condyle slants have been adjusted by means of the forward bite. This is especially important when using the Gysi Trubyte articulator, for the lateral plates on the incisal plane must be adjusted subsequently to fix the rotation centers. It may be remarked at this time that once the distal teeth are set as to their lateral and forward relations, they themselves may serve to induce the opening movements on an articulator such as the Wadsworth which does not possess the means of producing the opening movement in forward excursions.

To review briefly, the articulator and bite-plates represent as definitely set for the case in hand, the condyle guidance, the incisal guidance, the plane of orientation of the future dentures, and perhaps also the curve of the plane of occlusion. With teeth selected of suitable cusp length, it now remains only to arrange them and adjust them into this assembly. Once the articulator is set, the paths of movement of the bows of the instrument are definitely fixed (in imitation of the jaw of the patient) so long as the incisor guide pin remains in contact with its plane. It is during these movements that the teeth when set must exhibit sliding contacts, and it must be constantly borne in mind that these sliding contacts must be made by the prosthetist always with this pin in contact with its plane. We now have only the problem of placing the artificial teeth in such positions that they occlude properly in the rest position and, during the movements above specified, they exhibit the desired sliding contacts. We may now proceed to discuss the technic of arranging the teeth.

Technic of Articulation.—It is of first importance to correctly locate the positions of the lower teeth in respect to the alveolar ridge, for, with few exceptions, it is highly important from the standpoint of the stability of the denture that these be placed directly over the summit of this ridge.

Upon examining the lower cast we can note the crest of the lower alveolar ridge, and by making a mark with a pencil over this crest in the retromolar triangle and again a mark over it in the canine region and continuing with a third mark in line with the former two at a point outside the plate line as shown in Fig. 168, we have the means of recording this on the bite-plate.

The lower bite-plate is now returned to the cast and, with a rule connecting the first point marked on the cast with the third point, a line can now be scribed across the surface of the lower bite-rim which will indicate the summit of the lower ridge (Fig. 169).

On the buccal side of this line, 5 mm. away in the molar region and

3 mm. away in the premolar region, may be scribed a second line and, on the lingual side of the original line, 4 mm. in the molar region and 3 mm. in the premolar region, may be scribed a third line. The space between line 2 and line 3 will then give us the location of the upper bicuspids and molars, as in this position the force of mastication is brought directly upon the crest of the ridge in the lower jaw.

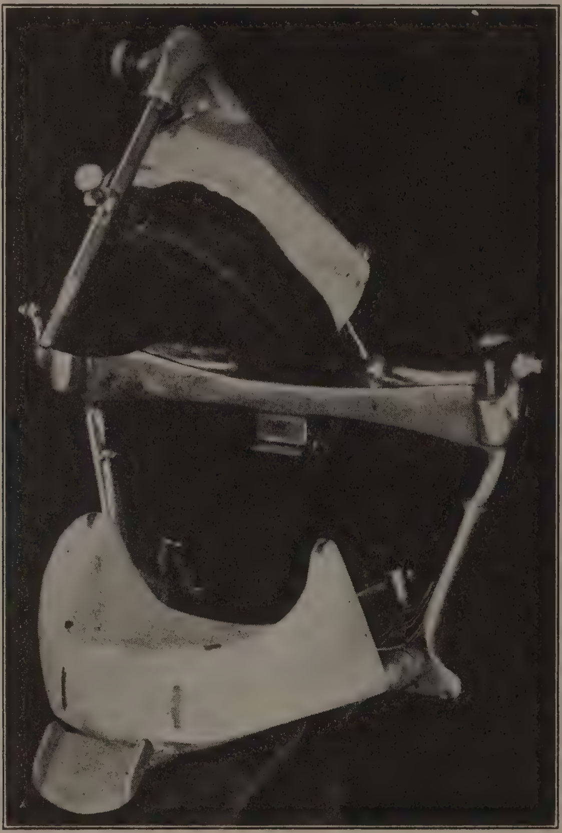

FIG. 168.—Lines drawn on lower cast to indicate center of alveolar ridge.

After these lines have been properly drawn, we are then ready to place the bicuspid and molar teeth in position. It is assumed that the six upper anterior teeth are already in place (Fig. 171). The molar and bicuspid teeth are now set with regard to their relation to the occlusal plane of the lower bite-plate as follows: The first bicuspid is placed so that the buccal cusp comes in contact with the occlusal plane, its lingual cusp being slightly raised; the second bicuspid is placed so that both cusps come in contact with the plane, the long axis of both of these teeth assuming a position vertical to the occlusal plane as far as their antero-posterior relation is concerned. The first molar is placed so that the lingual cusps come in contact with the occlusal plane but the buccal cusps are raised about 1 mm. or so off of the bite-rim; the second molar is placed with the lingual cusps in contact with the occlusal plane, while its buccal cusps are also raised, but to a greater extent than those of the first molar (Fig. 172). An examination of this relationship will reveal the approximation of a compensating curve, both antero-posteriorly and laterally.

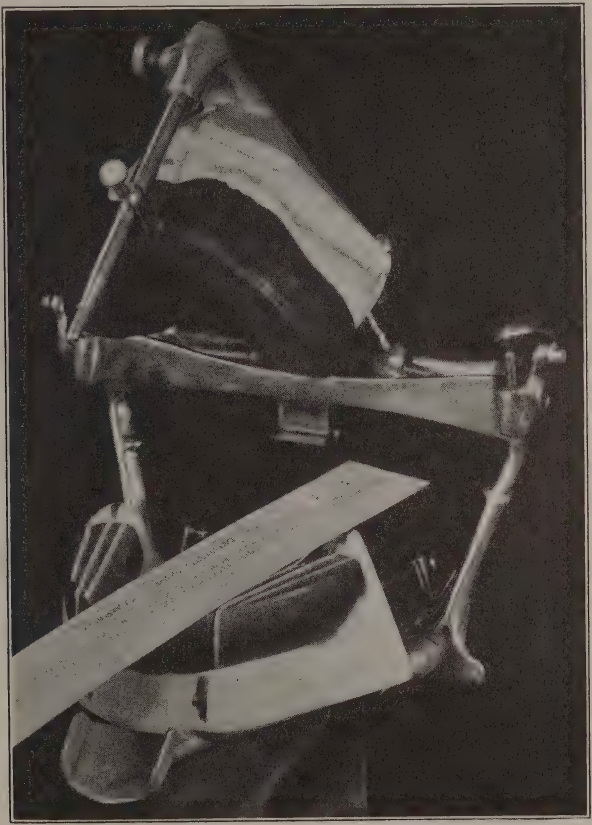

Fig. 169.—Lines on bite-plate to indicate position of distal teeth.

After these teeth are so placed (as in Fig. 173) the lower bite-plate may now be laid aside. Assuming that the first molar is the key to occlusion, we may start with the first molar in the lower jaw, mounting it on the lower base-plate with a ball of softened base-plate wax and bringing it into articulation with the second bicuspid and the first molar of the upper jaw (Fig. 174). The articulator may now be moved laterally and antero-posteriorly to test its contacts, and the

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lower molar adjusted in the finer details of a proper anatomical articulation.

The writers have found it advantageous to use for this purpose a small pair of soldering tweezers. The pair of tweezers being heated in the Bunsen flame will transmit enough heat when grasping the tooth to

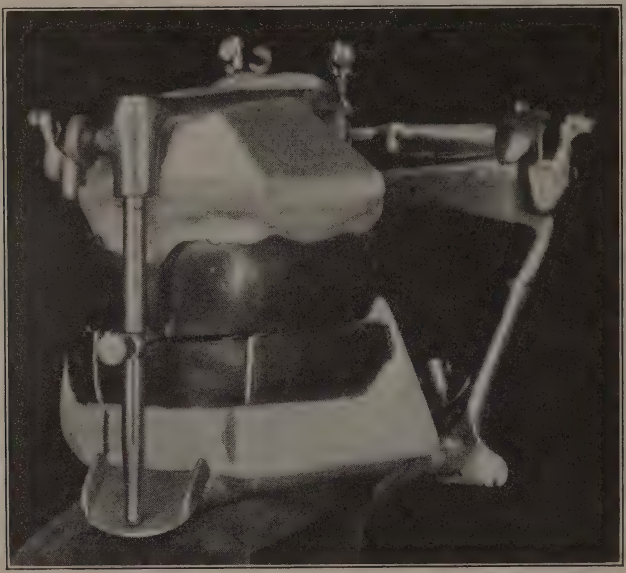

FIG. 170.—Bite-plates on articulator.

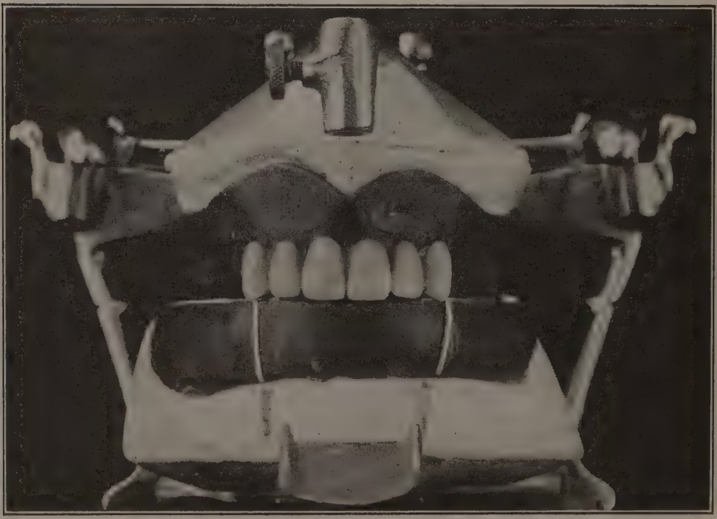

FIG. 171.—Six upper anterior teeth correctly placed.

allow the operator to move the tooth at will in the wax softened by the transmitted heat.

After the one molar has been properly placed, the one on the opposite side should be similarly placed and the articulator brought in right and left lateral occlusion to test the correctness of the working bite and the balancing bite. On account of the variations in the baking of porcelain teeth, it may be found necessary at times to slightly grind an individual tooth with a small carborundum stone to perfect the nicety of the interdigitation. After the two molars have been so placed, the second bicuspid on each side may be placed in like manner and also tested for their articulation, special care being taken to bring these teeth in contact with the distal surface of the upper first bicuspid, and the mesial surface of the upper second bicuspid when the articulator is placed in right and left lateral occlusion; also that the molar and bicuspid now placed assume a cusp to cusp relationship when the lower jaw is brought in the position of protrusion (Fig. 175). The first bicuspid is now placed in position on both sides, using the same technic (Fig. 176). After this tooth has been brought into correct articulation with the distal slope of the upper canine and the mesial slope of the first upper bicuspid, the articulator is again shifted into protrusion to test for correctness of cusp to cusp relations (Fig. 177). The second molar is now to be placed (Fig. 178) and it is here that we notice considerable difficulty in determining its exact position, as a slight incorrectness in its position will seriously affect the proper working and balancing bite. The operator will now observe that the positioning of the upper teeth as heretofore described will conform, with very little adjustment, to an articulation that is harmonious with the movements of the articulator (Figs. 179 to 183).

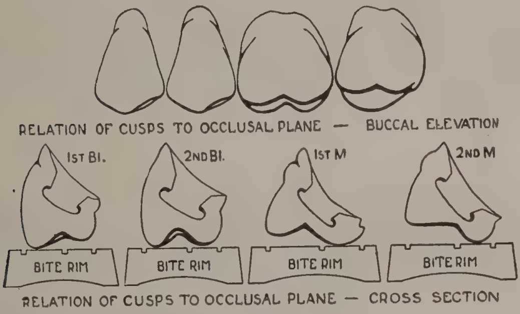
RELATION OF CUSPS TO OCCLUSAL PLANE — BUCCAL ELEVATION
1ST BI.
2ND BI.
1ST M
2ND M
BITE RIM
BITE RIM
BITE RIM
BITE RIM
RELATION OF CUSPS TO OCCLUSAL PLANE — CROSS SECTION

Fig. 172.—Diagram showing correct relation of cusps to lower bite-plate. (Clapp.)

The lower anterior teeth are now placed in position and if a correct record has been made of the lateral movements and the forward movement of the jaw and recorded in an instrument that is adaptable to these movements, the correct overbite will be easily found. The position of the six lower anterior teeth should assume the following

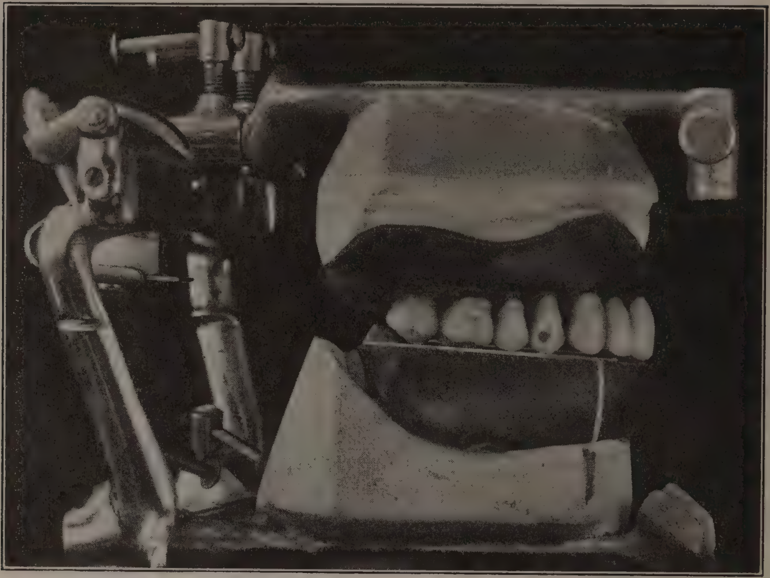

FIG. 173.—Distal teeth correctly placed.

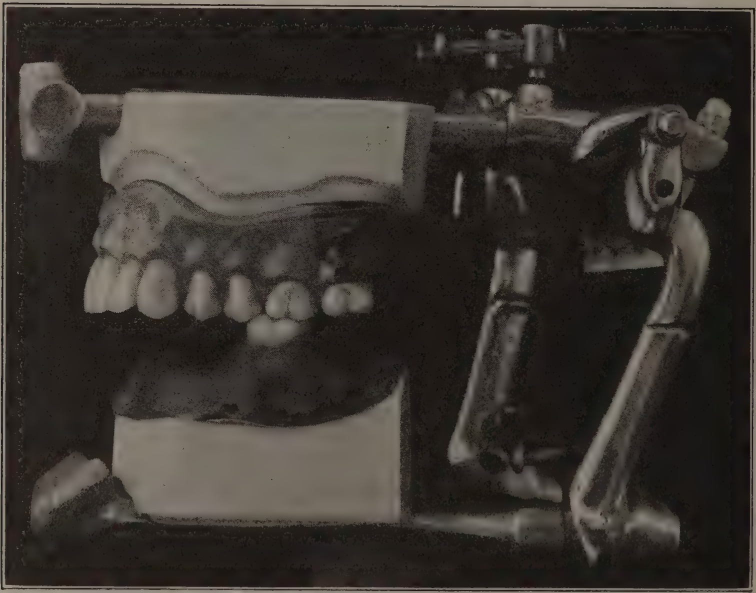

FIG. 174.—First lower molar in position.

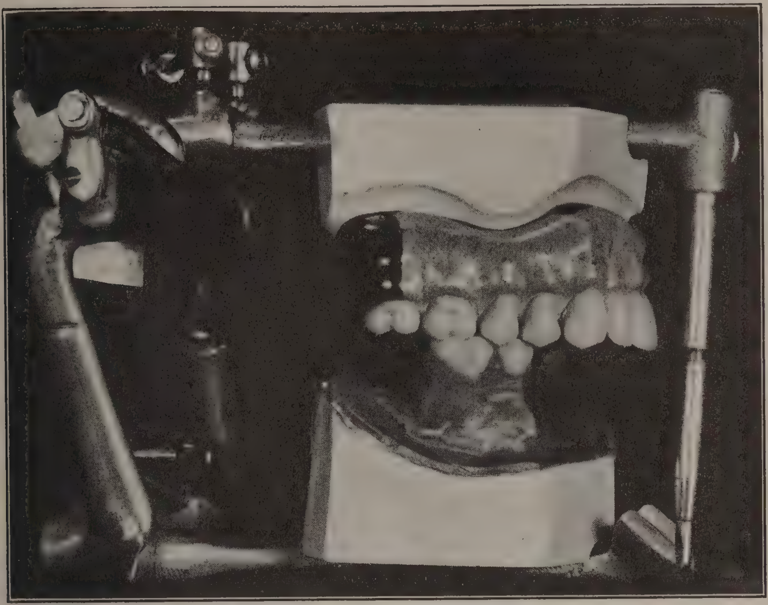

FIG. 175.—Second bicuspid placed in position.

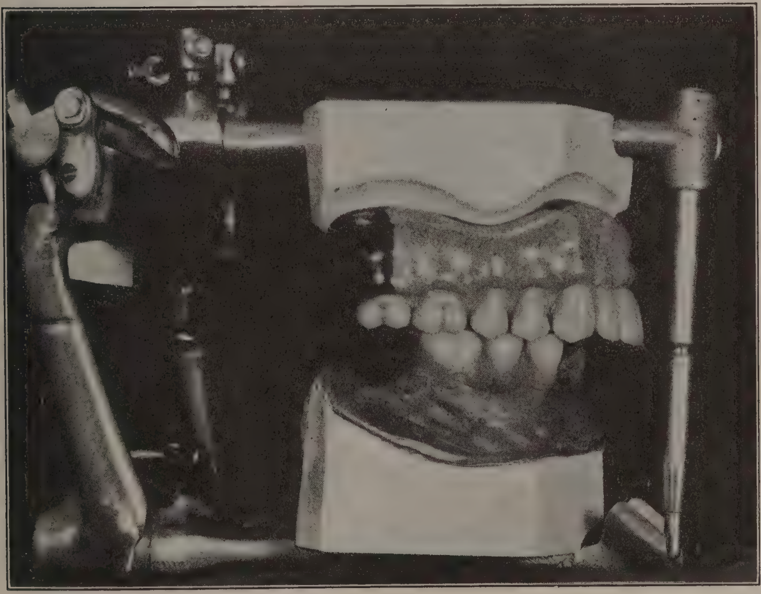

FIG. 176.—First bicuspid in place.

relations (except where it is advisable to copy certain individual characteristics): the long axis of the four anterior teeth should take a parallel relationship with the median line and the canines should be slightly

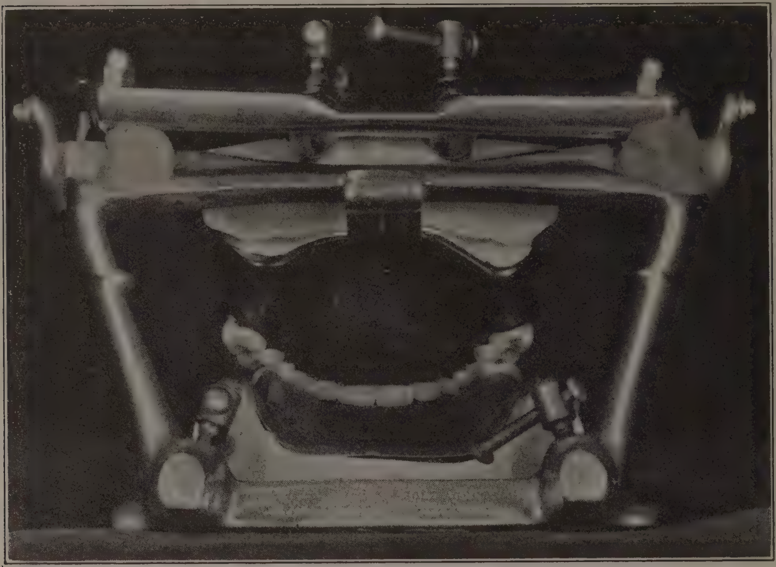

FIG. 177.—Testing relations of teeth in lateral occlusion.

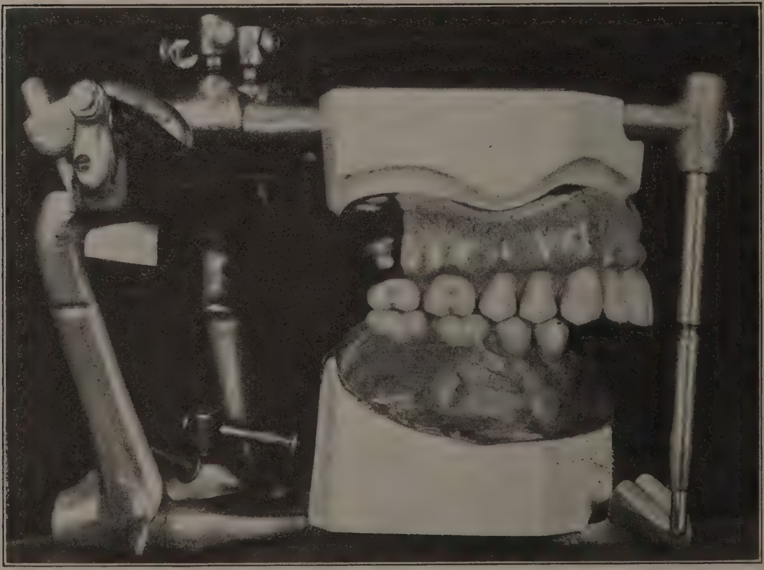

FIG. 178.—Second molar in place.

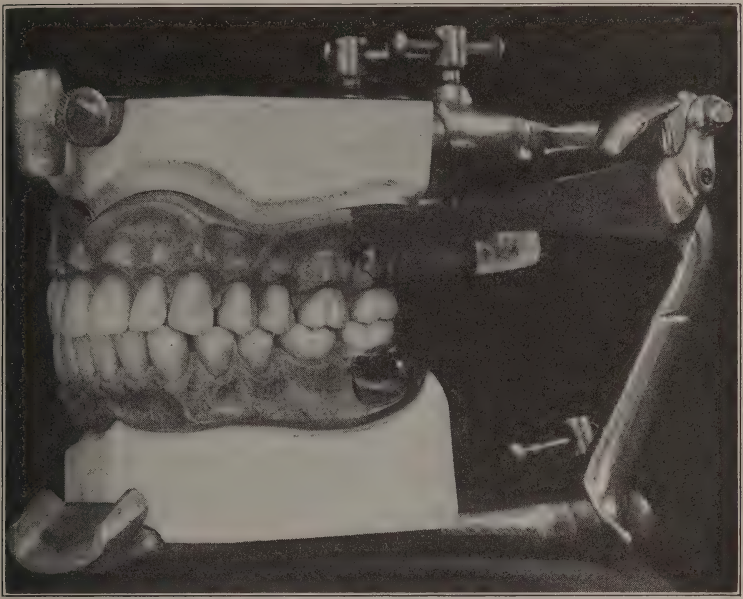

FIG. 179.—Upper and lower teeth in correct centric occlusion.

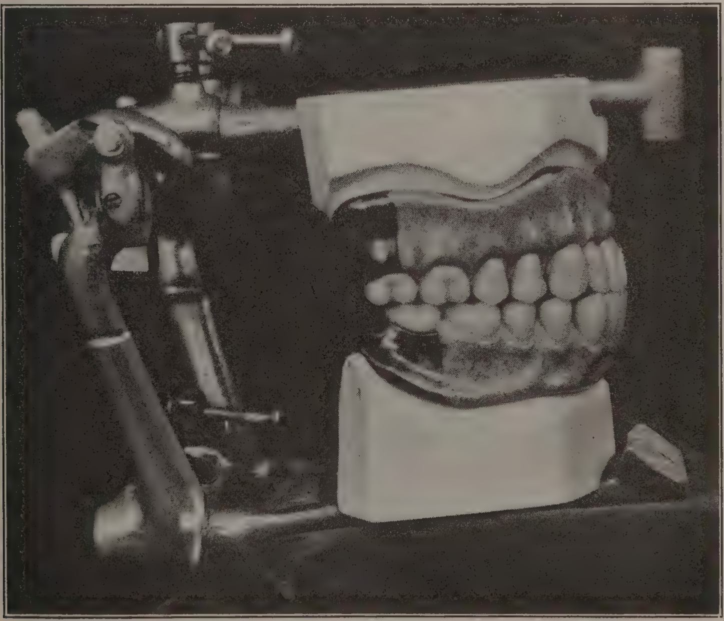

FIG. 180.—Incising relationship: Side view.

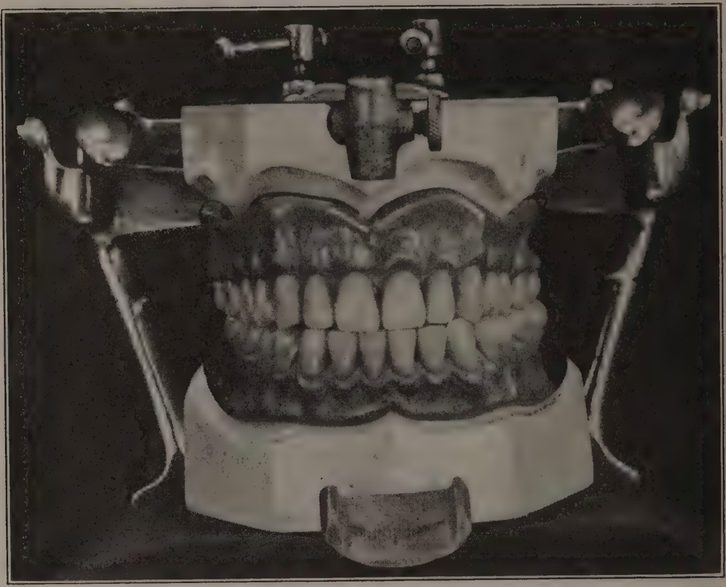

FIG. 181.—Incising relationship: Front view.

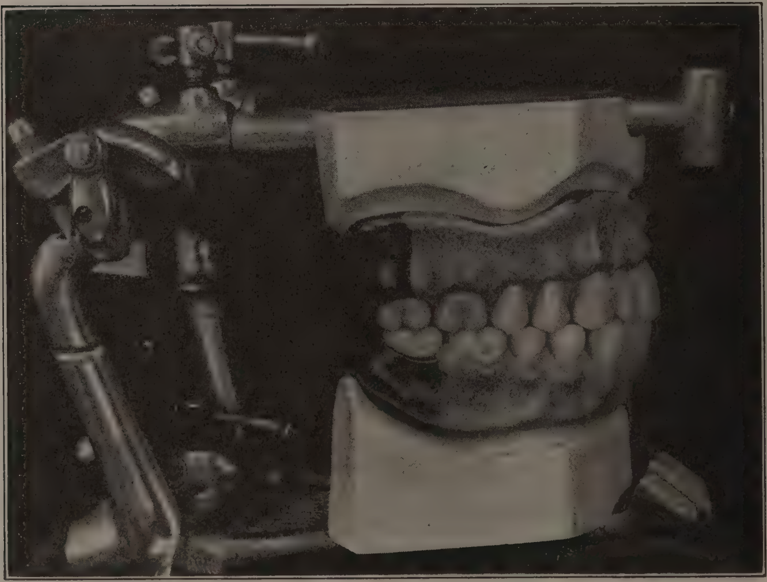

FIG. 182.—Relationship of cusps on working side.

tilted toward the median line (Fig. 184); as to their antero-posterior relation, the central incisors should be tilted slightly forward, the

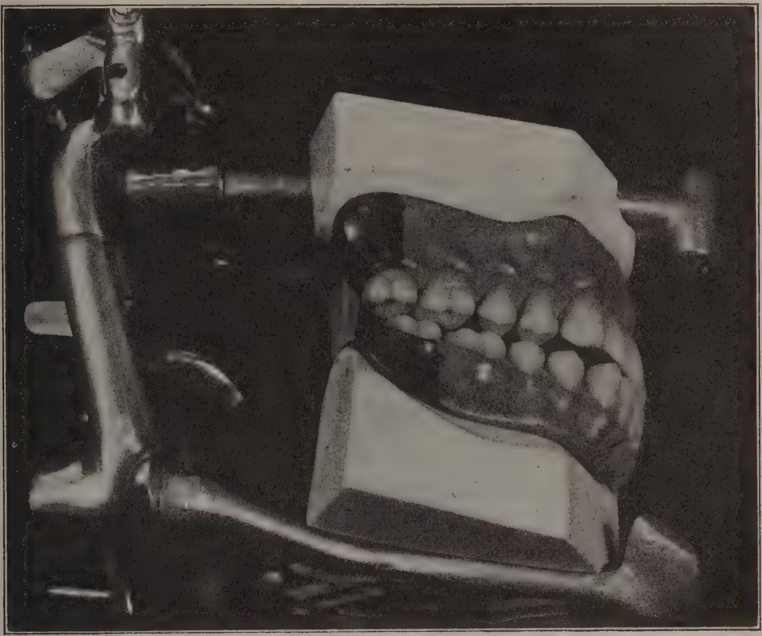

FIG. 183.—Contact relations of cusps on balancing side.

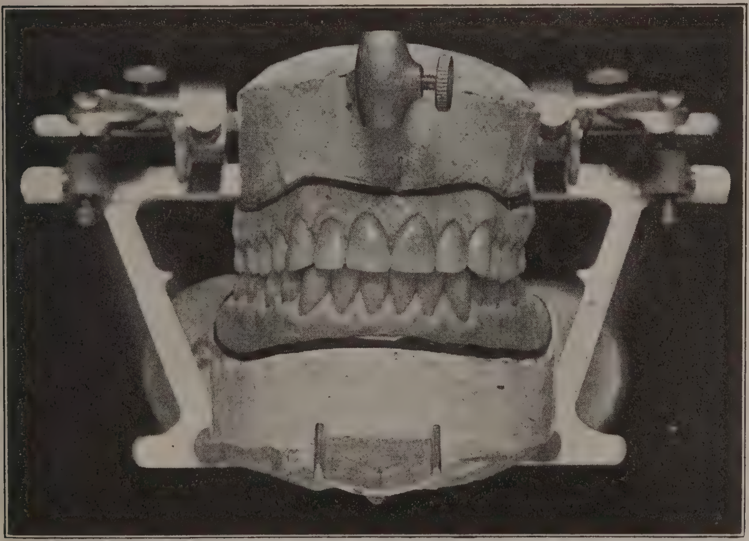

FIG. 184.—Front view of dentures in occlusion, showing positions of lower anterior teeth.

lateral incisors vertical, and the canines should be tilted slightly toward the lingual side, as shown in Fig. 185. These are now tested by shifting the articulator into lateral occlusion and also into forward occlusion (edge-to-edge bite). In lateral occlusion the three lower anterior teeth should come into occlusion with the upper teeth except the upper lateral incisor which is raised slightly off of the occlusal plane to avoid contact with the lower canine. As the lateral incisor of the upper jaw is extremely weak and subject to fracture, it is deemed advisable to raise this tooth slighly off of the occlusal plane to avoid too heavy a contact with its antagonist.

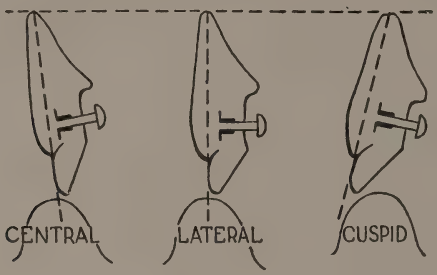

FIG. 185.—Proper relation of lower anterior teeth to alveolar ridge. (Clapp.)

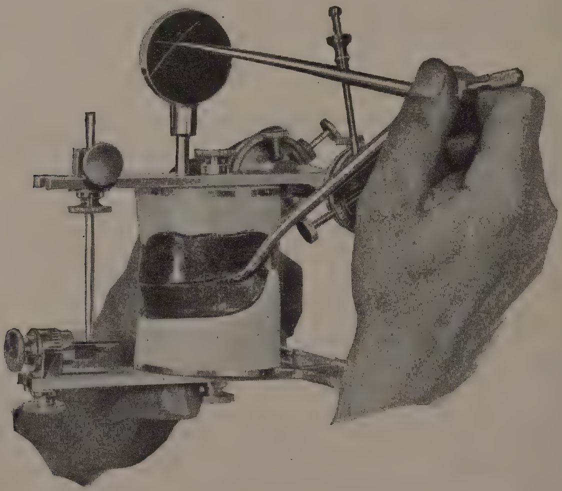

FIG. 186.—Scribing curve of occlusal surfaces on bite-plates by the Wadsworth method.

When these teeth are so placed, our next consideration is to test the entire articulation as to its correctness. The articulator is placed into left lateral occlusion and in this position the teeth on the right side should be in absolute contact from the central incisor on the right side to the second molar on the same side, with the exception of the upper lateral incisor which as before mentioned is kept out of contact. This side (right) is now in the position referred to as the working bite, while on the left side where the articulation is balanced by contact of the lingual cusps of the upper first and second molar with the buccal cusps of the lower molars, and this is referred to as the balancing bite (Fig. 183). If these contacts are correct, we can now test for the forward or protrusive relation, where the teeth to be in proper balance must exhibit an absolute cusp to cusp contact between all the teeth, with the exception of the upper lateral incisor as before mentioned. If these three relations are found to be correct, we may consider our articulation completed for a trial in the mouth as a further check. This trial will not only determine if the articulation is correct but will also check the accuracy of the bite relations.

Wadsworth's[1] method of carving the occlusal surfaces of the bite-rims into the antero-posterior and lateral curves is described as follows:

"With a pair of 5-inch dividers measure the distance from the median incisal angle to the condyle center. Then, with one point of the dividers on the condyle at the junction of the slot and condyle disc, scribe an arc on the modeling compound in the centering plate. Place one point of the dividers at the median incisal angle, and scribe another arc on the centering plate. These two arcs will intersect and the point of intersection will be the apex of an equilateral triangle, the base of which is a line between the median incisal angle and condyle center. The median incisal line is the furthermost forward point of the maxillæ and mandible, and the condyle is the most distal point. Therefore, the apex of the triangle above described becomes the exact center of the curve of occlusion.

"Place a point of the dividers at the intersection of the two arcs on the centering plate and scribe an arc on the bite-rims; this arc is the basic dental curve or curve of occlusion (Fig. 186).

"Cut away or add to the lower bite-rim whatever is necessary to conform it to the basic dental curve line scribed on the bite-rim. Then remove the upper model plate with model and bite-rim from the articulator. Close the articulator, and holding one point of the dividers at the apex of the triangle, gouge deeply into the lower bite-rim laterally with the other point of the dividers. This will register the trend of the lateral curve.

"Trim the bite-rim laterally to the bottom of the marks so made. Repeat the operation on the opposite side. Replace the upper model, with bite-rim, and build the upper bite-rim to conform with the planes established on the lower bite-rim.

"The arcs thus scribed will also coincide with the individual measurements of the distance from the median incisal angle to the condyles. This is a most important attribute of the Wadsworth instrument, which makes it possible to take practical advantage of the well-established anatomical fact that both sides of the mandibular triangle are rarely of equal dimensions."

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[1] Wadsworth Universal Articulator, S. S. White Dental Mfg. Co., p. 29.

With the bite-rims so carved or ground by the method of Essig and Paterson, the upper distal teeth may be mounted with buccal and labial cusps touching the bite-rims, when they conform to the antero-posterior (compensating) and lateral curves desired.

When finished the dentures are again tried in the mouth and are transferred from the mouth to the articulator with the face-bow, care being taken to check the accuracy of centric occlusion and to transfer the dentures to the articulator only in absolute centric occlusion. The dentures may now be fastened to the articulator model supports according to the face-bow record and the articulation finally adjusted by milling the teeth with carborundum paste. This will overcome any slight inaccuracy in cusp formation or error in bite relation.

TRIAL OF THE DENTURES.

Upon theoretical grounds after a set of artificial teeth has been articulated so as to have correct functional relations in the various movements of the lower bow of the articulator, they should be capable of correct functional relations in the mouth. The fact, however, that no articulator can perfectly reproduce the movements of the mandible in a given case, makes it advisable that after the dentures have been set up, their functional relations should be tested by actual trial in the mouth. This will frequently reveal errors in securing an accurate centric occlusal relationship of the jaws or other errors made up to this point. It is also desirable to determine if the shade and form of the teeth selected are satisfactory, and if their arrangement is pleasing. After the teeth have been temporarily mounted, therefore, they should be tried in the mouth of the patient.

The presence of the patient will probably, even under the best circumstances, provide additional data in the matter of the arrangement of the artificial teeth. In many cases no alteration of the original arrangement of the teeth will be necessary, but this depends almost solely upon the accuracy with which the conditions related to the arrangement of the teeth have been noted and the teeth set in accordance therewith. Frequently, however, the slight alteration of the positions of some of the anterior teeth to make them more fully accord with the principles already laid down for their arrangement, will be suggested when the teeth are tried in the mouth.

The articulation of the molar and bicuspid teeth in the excursions of the mandible may occasionally require slight adjustment because of the natural limitations in articulators already noted. A systematic examination of the dentures in place in the mouth should be undertaken according to a method recommended by O. A. Weiss.[1] First, the occlusion should be carefully noted, that is, it should be observed whether the teeth of the two series occupy the same relation to each other in the occlusal position of the jaw as they did in the articulator. It is not enough to depend solely upon the eye to judge of this, but the actual contact of the teeth must be tested by means of a thin instrument, such as a large hatchet-shaped excavator. The patient is instructed to lightly hold the jaws in the position of occlusion. The contact of the dentures anteriorly is first tested with the excavator. If the contact is uniform, posteriorly as well as anteriorly, prying the teeth apart with the excavator should also separate the distal teeth. It must be remembered, however, that the plates are to be held firmly in their positions upon the alveolar ridges, and the operator should not be deceived by finding the plates apparently in contact posteriorly when they may be separated in front. The dentures may be detached from the membrane posteriorly, the teeth apparently being in contact, when the anterior teeth are separated by this measure. The contact of the distal teeth on both sides should be tested in a similar manner. The displacement of the dentures anteriorly by separating the posterior teeth with the excavator is not likely to occur from this procedure. When the distal teeth are separated, the jaws should be pried apart and the anterior teeth should also be similarly separated. This should be tested on both sides. If a serious lack of adjustment is made manifest by this trial, the bite should be retaken and the teeth reset.

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[1] The Dental Review, September, 1903.

In testing the relation of the teeth in the various movements of the mandible, the same general method of procedure may be undertaken. The patient is directed to move the mandible to the right and bring the teeth in contact with this position, the condyle on that side remaining in its fossa. On the right side the two lines of buccal cusps should be in contact, while at the same time the lower buccal and upper lingual cusps are in contact on the left side. The contact is to be tested with the excavator unless it is seen that the teeth do not occupy these relations. If, on the right side, the cusps are not in contact, but are separated, while they touch on the left, it is evident that the cusps on the left side are too prominent or that those on the right side are not sufficiently so. This defect may be corrected by changing the inclination of the long axes of the teeth on the left, so that at the same time that the cusps on the right side are in contact, those on the left are also.

If, on the contrary, when the mandible is moved to the right, the cusps on that side are in contact and those on the left are not, the long axes of the teeth on the left side should be altered so that the buccal cusps of the lower and the lingual cusps of the upper are made more prominent and come into contact. It will be evident that these alterations must be made with the plates in their place upon the articulator, and without alteration of the occlusal relations of the casts.

This operation is to be repeated with the mandible moved to the left, and any adjustment in the direction of the long axes of the teeth on either side made in accordance with the above principle.

The relation of the teeth when the jaw is protruded for incision should be tested. The patient is directed to bring the occlusal edges of the incisors into contact and to maintain the jaws in this position. The contact of the distal teeth is then to be noted, the excavator being again employed to discover if they touch. If the molars are in contact, as determined in this trial, then no alteration is to be made in the position of the teeth. If, however, they are not in contact, it will be seen either that the overbite of the upper incisors is too great or that the compensating curve of the molar and bicuspid teeth does not accord with the path of the condyle. This defect may be corrected either by reducing the overbite until the incisor and distal teeth are in simultaneous contact in this position of the mandible, or by arranging the distal teeth with a compensating curve of shorter radius.

If in the protruded position of the mandible the anterior teeth are not in contact, then the overbite is not proportioned to the compensating curve and the length of the cusps of the distal teeth; or the compensating curve has been arranged with too short a radius; or its distal end is below the line proper for the compensatng curve. Adjustment of these defects may be made and the dentures returned to the mouth for confirmation of the changes.

The restoration of the facial contours and profile by the dentures should be tested at this time also and any alterations which may be indicated should be made.

THE ARRANGEMENT OF TEETH IN ABNORMAL PROTRUSION OF THE LOWER JAW.

"In the preceding illustrations and text the attention of the student has been directed to normal conditions, and the normal arrangement of artificial teeth with those conditions, in order that he may familiarize himself with the various methods and principles involved, and be able to modify them in the treatment of abnormal cases.

"Fig. 187 shows an extremely abnormal relation of the alveolar ridges and one requiring a considerable modification of the usual methods in order to arrange the teeth in a manner at all satisfactory. A protrusion of the lower jaw, however, with certain limits may be met with occasionally, and a normal arrangement of the teeth obtained, providing that other conditions are favorable to it. But, before attempting to arrange the teeth in such cases, and while the patient is still at hand, the operator must make some careful observations.

"First, to ascertain whether the lower teeth can be retracted sufficiently to obtain an overbite without interfering with the movements of the tongue.

"It is seldom possible to adjust the lower teeth toward the tongue further than the center of the edentulous ridge. If such an operation is attempted, the movement of the tongue will not only be impeded and speech impaired, but the stability of the denture will be affected by the tongue constantly pushing against it.

"Second, it must be ascertained whether the tissues of the upper lip are sufficiently lax to permit of bringing the upper teeth to the necessary distance forward from the alveolar ridge to obtain an overbite.

"Third, will the removal of the superior incisor teeth from the alveolar ridge cause a continual loosening of the denture by excessive leverage on these teeth?

"Fourth, whether the attempt to obtain a perfect profile will effect too radical a change in the patient's appearance.

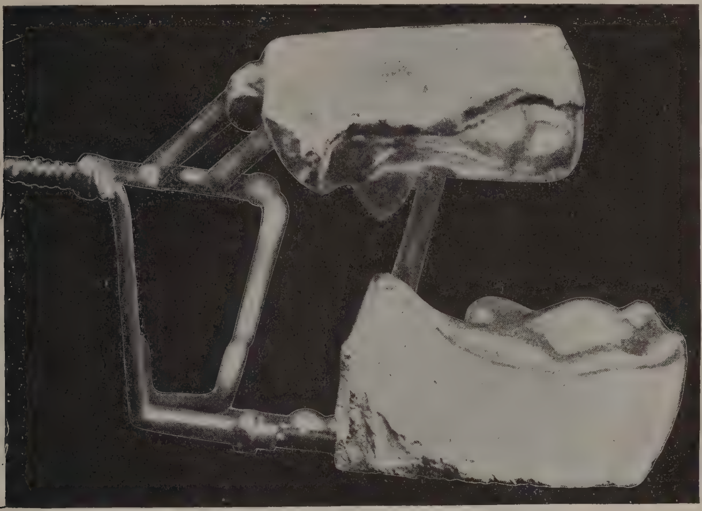

FIG. 187.—Showing extreme protrusion of the lower jaw, and with antagonizing casts on the anatomical articulator.

"Fig. 188 illustrates the arrangement of teeth necessary in case of protrusion so extensive as in Fig. 187. The upper incisor teeth are arranged to close inside of the lower, with their labial surfaces gliding closely on the lingual surfaces of the inferior incisors, the incisive function being performed in a reverse manner to that of a normal arrangement.

"When the upper canine tooth is reached, the first attempt is made to merge into a normal arrangement.

"This tooth is placed with its anterior cutting edge covered by the lower canine, while the distal cutting edge is turned labially and ground so as to strike directly on top of the mesial cutting edge of the first lower bicuspid. The first upper bicuspid, is ground and brought out slightly more than the canine, and from this point distally the teeth assume their normal position. In order to obtain a graceful arrangement in such a case as seen in Fig. 188, it will be necessary to do considerable grinding and lapping of the upper teeth, which is not at all unsightly in this character of case."[1]

It will sometimes be found necessary in cases of lower protrusion, when the difference in size of the jaws is too great, to use what is called a "cross bite." In such instances a normal occlusion would demand that the upper teeth be set too far off the ridge buccally, or the lower teeth too far off lingually. To avoid this and provide a better mechanical arrangement, the posterior teeth may be reversed.

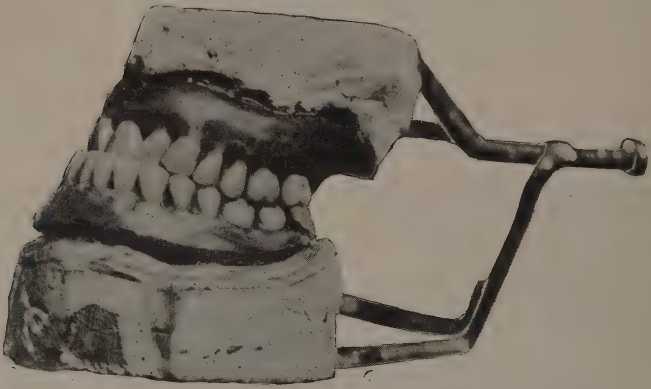

Fig. 188.—Showing the arrangement of the teeth necessary in a case when the lower teeth close outside of the upper.

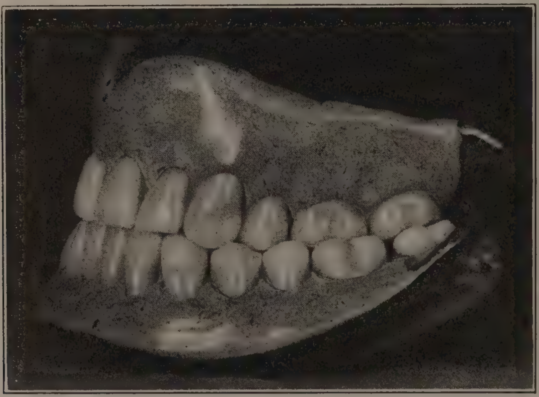

Fig. 189.—Arrangement of teeth in a case of "cross bite."

After the anterior teeth have been set, the distal teeth are arranged in the following manner: The upper right posterior teeth are placed on the lower left side, the upper left posterior teeth on the lower right side, the lower teeth being similarly transposed to the upper plate to occlude with their corresponding teeth. This change necessitates the omission of the first bicuspid from the upper plate to provide for a proper interdigitation of the cusps. A balanced articulation is usually possible (Fig. 189).

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[1] American Text-book of Prosthetic Dentistry. Second Edition, p. 412.

"The facial expression following such an arrangement of the teeth will be improved. In marked protrusion of the lower jaw, where the natural teeth close outside of the upper and when this condition has existed up to middle life with natural teeth, a correction of the facial expression with artificial teeth should not be attempted."[1]

THE ARRANGEMENT OF TEETH IN ABNORMAL PROTRUSION OF THE UPPER JAW.

In the arrangement of teeth of a full upper and lower denture in protrusion of the upper jaw, it is seldom possible to secure the ideal relations existing between the teeth of the two series when the jaws occupy a normal relationship. In most instances in which the lower jaw had a retruded position when the natural teeth were in place, after their loss, with the consequent resorption of the alveolar process, the increase in the angle of the mandible, and its forward movement, a normal relationship between the two series can be obtained. A few cases present themselves, however, where the placing of the artificial teeth in somewhat the same relative positions occupied by their natural predecessors is necessary. In these cases the upper anterior teeth should have a slight lingual inclination (Figs. 190, 191, 192, 193, 194). The lower anterior teeth should not be placed in occlusal relations with

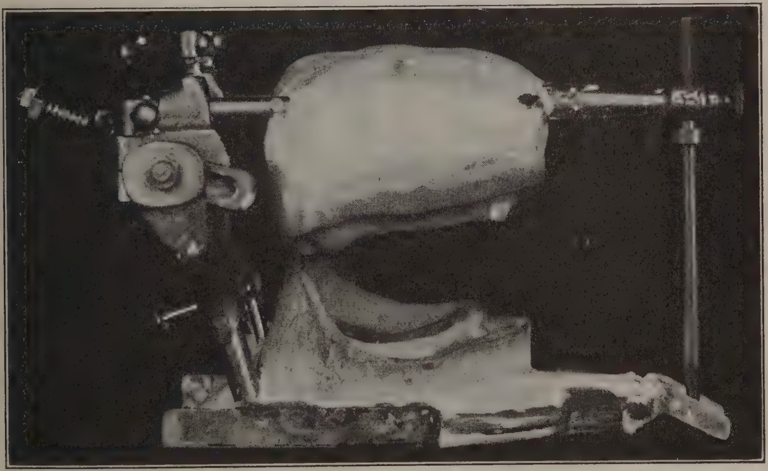

FIG. 190.—Casts of case of upper protrusion.

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[1] Loc. cit.

them, if it is necessary to give them a labial inclination. The lower teeth are to be made to bite upon the lingual surface of the upper plate.

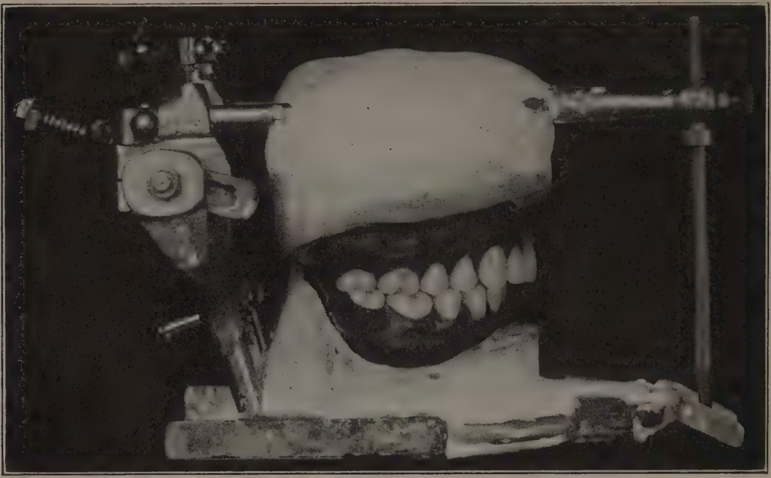

Fig. 191.—Arrangement of teeth for case illustrated in Fig. 190.

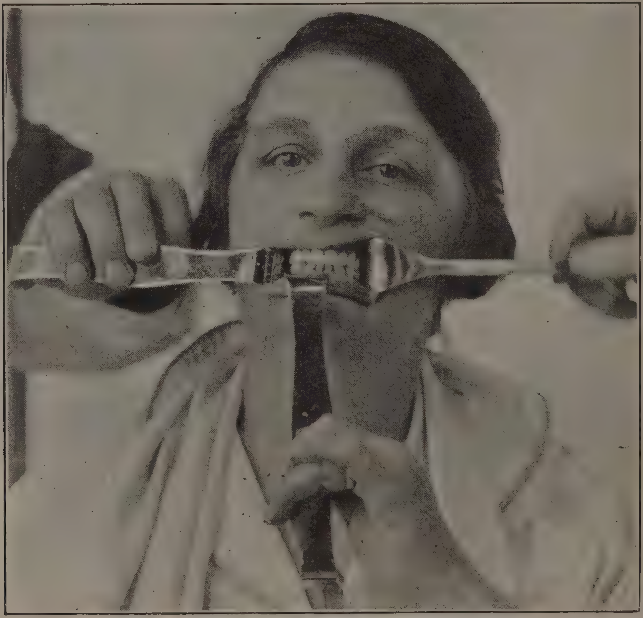

Fig. 192.—Dentures illustrated in Fig. 191 in mouth of patient.

The molar and bicuspid teeth are to be articulated according to the anatomical principles already outlined, wherever this is possible. In every instance the cusps should be made to interdigitate, even if this requires the placing of the lower teeth the width of a cusp distal to their normal position. This condition of occlusion is frequently observed in the natural dentures.

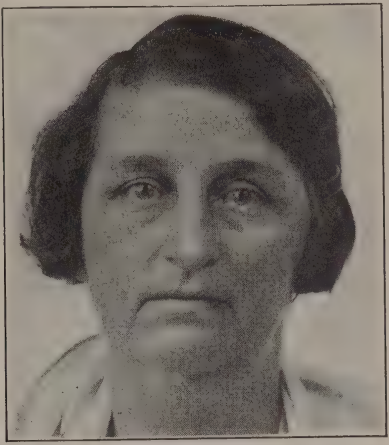

Fig. 193.—Front view of patient; same as Fig. 192.

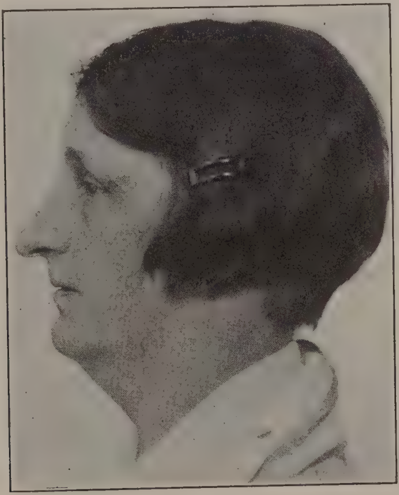

Fig. 194.—Side view of patient; same as Fig. 192.

The commonest cases of retruded lower jaw which present for treatment are those with the natural teeth remaining in position and preventing, by the nature of their occlusion, the forward movement of the mandible. In these instances the difficulties of obtaining good occlusal relations between the teeth are greatly increased, and usually the operator has to be satisfied with an arrangement far short of the ideal.

THE ARRANGEMENT AND ARTICULATION OF A FULL UPPER DENTURE TO NATURAL TEETH.

Cases frequently present themselves for treatment in which the patient has lost all of the upper teeth, while all or a large number of the lower remain in the mouth. While the general principles underlying the articulation of teeth for full upper and lower dentures are applicable in these cases, certain additional considerations are to be noted.

When all the lower natural teeth remain, the articulation of an upper artificial set is a comparatively simple matter. One of the two series of teeth is in place; it is only necessary to arrange the other to accord therewith. While it is usually necessary to mount the casts in correct relation with the joint of an anatomical articulator which has been set according to the movement of the mandible for the case in hand, yet the necessity for so doing is not so great as in full dentures. This is because of the fact that the forms of the occlusal surfaces of the natural teeth are either in accord with the jaw movement, usually in such cases having been much worn, or if they are not, they cannot be altered, and the form of the occlusal surfaces of the artificial teeth must be largely determined by them. Still it is preferable to use the anatomical articulator, because the occlusal relations may be more certainly determined.

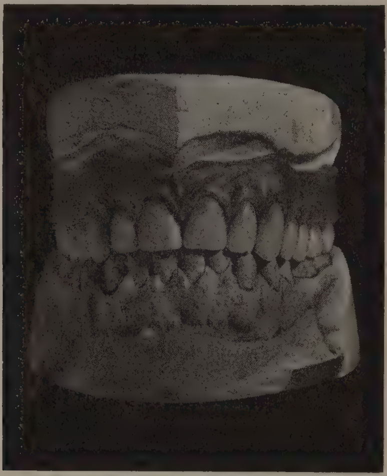

Fig. 195.—Full upper denture arranged to occlude with lower natural teeth.

In the arrangement of the anterior teeth advantage may often be obtained by placing them in edge-to-edge occlusion with the lower teeth (Fig. 195). They are ground to articulate upon the worn edges of the lower teeth and must be made to accurately fit these edges as if they had been worn into shape in the mouth. This arrangement enhances the stability of the plate by avoiding the leverage due to an overbite but is not possible in every case, because the distance between the lower teeth and the upper alveolar ridge may not permit the placing of a tooth of the proper size. Nor is it indeed always advisable from considerations relative to appearance. The arrangement of the artificial teeth with an overbite is demanded in such instances, but the overbite should be as short as possible. Where the lower jaw occupies a retruded position, however, it may be necessary to have a long overbite with a lingual inclination of the upper teeth, but in such instances, a firm retention of the upper plate should be assured and a space left between the upper and lower teeth to avoid displacement of the upper denture.

The molar and bicuspid teeth should be ground to correspond to the state of wear of the natural teeth and should be made to occlude evenly upon them. Many dentures of this type are seen in which the teeth have been articulated without alteration of their form, the long sharp cusps of the artificial teeth occluding upon much abraded lower natural teeth. The functional disadvantage of such an arrangement is manifest.

Where only the lower anterior teeth remain, and these cases are of common occurrence, the principles already laid down for the correct articulation of the artificial teeth may be followed out almost completely. It will be remembered that the lower anterior artificial teeth in full dentures are the last ones to be placed in position. In the case under consideration the natural teeth serve as a starting point in the arrangement of the artificial teeth, which latter may be made to accord with the former. The slight settling of the lower partial denture should be borne in mind and anticipated by arranging the upper teeth just short of occlusion with the natural organs.

This type of case illustrates particularly well the necessity for complete restoration in every case which presents itself. In these instances, if the lower partial denture is not made, the whole function of mastication is thrown upon the natural teeth and the upper plate. In the course of time the pressure upon the anterior portion of the upper plate will cause a resorption of the alveolar process underlying it. The mucous membrane in the anterior part of the upper jaw will become soft and spongy and readaptation of the plate may be necessary. This latter procedure will be complicated by the softness of the tissues over the absorbed process, and it will be difficult to obtain satisfactory results. On the other hand, if a lower partial denture had been inserted, the condition alluded to would have been avoided.

TEMPORARY DENTURES.

While in the strictest sense of the term all dentures are temporary, as greater or less change is constantly going on in the process, reference is here made to dentures inserted within a short time after the extraction of the teeth. Temporary dentures are to be advised in every instance in which there is not some contraindicating condition. They may be inserted either immediately after the extraction of the teeth before the inflammatory reaction incident thereto has subsided, or they may be inserted after the inflammation has ceased and before the resorption of the process has appreciably progressed. They serve to provide the patient with a masticatory apparatus and avoid a period in which the patient is seen without teeth.

The selection of teeth appropriate for these cases has already been discussed. If it is desired to insert the plate immediately after the extraction of the teeth, an impression must be taken and a cast made with the natural teeth *in situ.* The plaster teeth are then cut from the cast, which is carved to represent the conditions after the teeth shall have been extracted. The anterior artificial teeth are to be mounted in the sockets of the natural ones. The cast is carved to permit this. Anticipating to some degree the resorption of the external plate of the process, the artificial teeth are to have the portions which are to be in relation with the cast so ground that their necks project into the socket, and yet after the external plate has been resorbed, they will be in relation with the labial surface of the process. The distal teeth are to be mounted in the usual relation with the alveolar ridge. The buccal portion of the plate is to be made as for full dentures, but should not extend farther forward than the center of the first bicuspid. Of course no portion of the plate is to extend over the unresorbed process anteriorly.

II. VOICE AND SPEECH RELATIONS.

It is desired that artificial dentures shall restore any lost portions of the apparatus necessary in the production of articulate speech, and, in addition, shall offer no impediment to the normal articulation of sounds. It is desired also that they shall produce the least possible alteration in the tones of the voice.

It has been seen in Chapter I that the loss of the teeth and the changes in the surrounding tissues incident thereto, cause but slight alteration in the quality of the voice, that speech is chiefly affected by these conditions, and that the production of the vowels is less affected than the production of the consonants. It was seen, further, that the chief alterations of conditions affecting consonant production are the loss of the tissues upon which the current of air is projected, or of those at the site of which the current of air is stopped, and the loss of tissues concerned in the formation of the channel through which the air is forced. It is with the remedy of these conditions that we are chiefly concerned, and at the same time the artificial denture must be designed to offer the least possible impediment to the articulation of all sounds.

Slight alterations of the tones of the voice will occur when any artificial denture is placed in the mouth of a patient. These are, in many instances, so slight as to be indistinguishable, while in others the difference may be sufficient to be appreciated. This consideration, however, is of comparatively small importance in the design of dentures, for the reason that it is impossible to place an appliance of any sort in the mouth without producing some slight changes in the voice tones. Thinness of the plate which covers the palatal vault contributes more than anything else to a retention of the normal voice qualities. It is for this reason that a metal plate causes less change than a plate of one of the molded bases.

In designing a denture to fulfil all the requirements of speech, the following fact must be noted: The factors concerned in the speech relations of a denture are the form, location, and arrangement of the teeth, and the lingual conformation of the upper and lower dentures. These factors are to be so adjusted to the case in hand as to permit a free movement of the tongue, and the correct formation of the air channel, and provide for the obstruction of the air current at the proper places.

Fortunately the form and arrangement of the teeth to answer the requirements of appearance and food preparation, in general, best serve the ends to be desired from the standpoint of speech production. There are a few exceptions to this principle which are to be noted. The arrangement of the upper and lower anterior teeth with a slight space between them to prevent contact and consequent displacement of the denture, recommended by some practitioners, interferes occasionally with the articulation of the sounds in which the current of air is interrupted at this point. The tongue is called upon to close up the deficiency caused by a lack of contact of the teeth in the production of the sound, for example, an adjustment which it is usually possible for it to execute.

The bicuspids and molars for considerations of plate stability frequently intrude upon the space required by the tongue in its adjustments; a consequent cramping of this organ occurs with a certain thickness of speech which persists until the individual has adapted himself to the abnormal conditions.

Freedom in the movement of the tongue may sometimes be prevented by an impingement of the plate upon its frenum. It has already been seen that this condition is to be avoided upon another ground—that of the displacement of the denture.

A common error in the conformation of the lingual surface of lower plates causes a limitation to the movement of the tongue. Where the lower molars and bicuspids are placed to the lingual side of the ridge to occlude with those of the upper jaw in mouths in which great resorption of the process has occurred, the narrowness of the plate restricts the tongue movements necessary to correct articulation. It not infrequently happens that the lower plate itself intrudes upon the space proper for the tongue. These conditions are to be avoided if possible. It is often necessary to compromise the demands of plate stability with those of speech production. This situation arises in a large number of lower dentures constructed for months in which considerable resorption of the process has occurred. In these instances the arch of the teeth should be as wide as is consistent with plate stability, and at the same time the lingual surface of the lower plates should be made as concave as possible to provide adequate space for the tongue. It is in these cases that the employment of the "cross bite" is particularly valuable.

When the lingual conformation of the upper plate copies as accurately as possible the form of the natural tissues, the conditions most favorable to articulation are established. Large numbers of vulcanite dentures are made with a smooth dome-shaped lingual surface, to which the tongue can adapt itself in the formation of the air channel with less ease than if the conformation of the natural tissues were reproduced. In the formation of the TH, T, D, S, SH, C, Z, ZH sounds, the sides of the tongue are curled up to come in contact with the teeth and adjacent alveolar process to form the channel through which the air escapes. It has been seen that the form of this channel largely determines the consonant sounds. While the tongue can adapt itself to changed relations of other tissues taking part in the formation of this channel, as the enunciation of patients wearing dentures constructed regardless of these conditions abundantly testifies, yet it is not wise to impose too much upon the tongue in this way. The more nearly the lingual surface of the plate corresponds to the form of natural tissues, the more readily will the tongue be capable of affecting correct adjustment to them. With this end in view it is advisable in vulcanite dentures to reproduce the lingual surfaces of the teeth, either by the use of teeth formed to reproduce the lingual surfaces of natural crowns or by the imitation of these surfaces with the vulcanite[1] (Fig. 196). The imitation of the rugæ on the lingual surface is to be referred to presently.

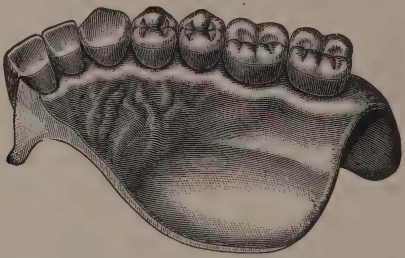

Fig. 196.—Lingual surfaces of teeth reproduced in vulcanite. (Fine.)

The projection upon the lingual surface of a metal plate caused by the vacuum-chamber seldom interferes with correct speech production. This is for the reason that if properly located and of only the required depth, it does not prevent the formation of a sufficiently large channel for the air. The tongue, of course, has to adjust itself to this condition of affairs, but the adjustment is made with comparative ease. Furthermore, if properly located, the vacuum-chamber is posterior to the point of interruption of the air channel in the formation of the T, D, S, C, Z, SH and CH sounds.

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[1] Dr. W. M. Fine, International Dental Journal.

The conformation of the lingual surface of the upper plate to facilitate correct speech has been well described by Dr. George B. Snow. The following is requoted from a paper published in the *Dental Advertiser* in 1899. "Trouble is often experienced by patients in securing a clear and sharp S sound after they have commenced the use of artificial dentures. A peculiar whistling sound is produced. It is now proposed to give a short description of the mechanism by which these sounds are produced, and to draw attention to the importance of giving due consideration to the shape of the lingual side of the plate, if it is desired to secure clearness and ease of articulation of the sound above referred to.

"Inspection of models of the upper jaw in which the natural teeth are in place will show that while the lingual surface of the bicuspids and molars practically forms a continuation of the lateral curve of the palatal arch, the alveolus behind the incisors is thickened. With the rugæ a nearly triangular space is oftened produced, bounded by a line connecting the distal surfaces of the laterals and the edges of the alveolar sockets. Viewed in longitudinal section, a reversed curve is presented, extending forward from the hard palate and merging into the hollow outline of the lingual surfaces of the incisors.

"Section of model from a mouth is shown in Fig. 197.

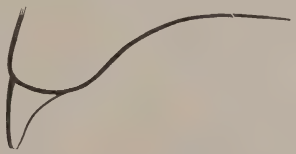

FIG. 197.—Section through cast showing thickened alveolar process back of incisors.

"In Figs. 198 and 199 an attempt has been made to show the relative positions of the tongue and teeth in making the S and SH sounds. In producing the SH sound (Fig. 199), the upper and lower teeth are held slightly apart; the tip of the tongue rests against the gum behind the lower incisors, its edges impinging upon the lingual surfaces of the bicuspids and molars at their junction with the alveolus. The result is a narrow passage over the center of the tongue, the narrowest portion being just back of its tip, the passage being thus gradually enlarged both behind and before its narrowest portion. The breath, being forced through this narrow passage, follows its curve, and is impelled against the tips of the lower incisors, the result being the SH sound.

"In giving the S sound (Fig. 198), all the parts remain in the positions above described, except the tip of the tongue, which is curved upward to the alveolar border on the lingual side of the upper incisors, making the passage smallest at its outlet and projecting the current of air against the upper incisors. It will be found by experiment that if the tongue is drawn backward a little from the position described, the hissing sound will be changed to a whistle. It will be noticed that the shape of the palatine arch is such that the tongue can readily conform to it, and that the passage between the tongue, palate, and alveolar border can be readily formed, by which a clear articulation of the sounds in question can be produced.

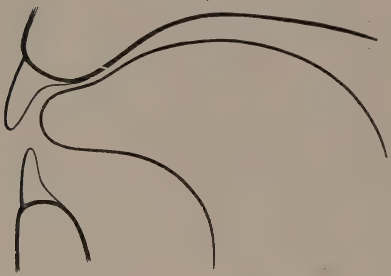

Fig. 198.—Position of tongue in pronouncing S.

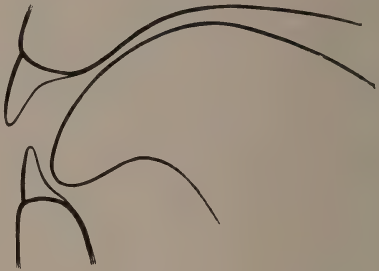

Fig. 199.—Position of tongue in pronouncing SH.

"As a contrast to the figures already shown, attention is directed to Fig. 200, which is a section of a fairly well made vulcanite plate. The teeth are well arranged, the joints close and well fitted, the finish good. It will be observed that the palatal curve, if continued, would meet and coincide with the curve of the lingual surfaces of the incisors, there being a break at the point of junction of the teeth and rubber; and this is so abrupt that it would be impossible for the tongue to follow its outline, as it does the curve of the natural arch in Figs. 198 and 199. The reversed curve, shown in Fig. 200, is plainly out of the question. The sketch illustrates what is by no means an extreme case. With thinner teeth and a longer bite, the defect noted would be still greater.

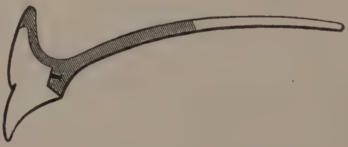

Fig. 200.—Section through vulcanite plate.

"If the imitation of Nature be carried far enough to reproduce the rugæ upon the plate, it will be found to be a decided benefit both to articulation and in the management of food in mastication. When the lingual side of the plate is smooth, the tongue has but little power to hold a morsel of food upon it, while with the rugæ the food is easily held and managed. They are easily formed by burnishing a piece of heavy tin-foil over a model showing them prominently, filling the depressions in the tin-foil with wax or paraffin, and then fitting and attaching it to the trial-plate when waxed up and ready for flasking, leaving its edges turned up so that it will be held securely in the plaster when the plate is flasked. The surface of the vulcanite will come out clean and smooth and will require but little polishing. It will be found that a patient who has once become accustomed to the use of a plate made as above suggested will be extremely loath to return to the use of one as ordinarily made."

III. THE RELATION OF PLATE DENTURES TO THE EXPRESSIVE MOVEMENTS OF THE FACE.

Besides restoring the fixed expression of the face, plate dentures must establish conditions which admit of the normal activity of its expressive movements. It has been shown in Chapter I that the following conditions resulting from the loss of the teeth affect these movements: A change in the relation of the jaws and the withdrawal of the normal support provided by the teeth and alveolar process for the lips and cheeks; the restriction of the movement of the lips and cheeks in the associated group of muscular movements which give expressional significance to the face. Artificial dentures are to establish such conditions as will permit the normal operation of these movements.

In the design of the dentures to answer the above-mentioned requirements, the following factors are to be considered as promoting the desired ends. The relation between the jaws is established in the position of occlusion by the dentures. The support of the lips and cheeks is furnished by the positions of the teeth and the contours of the buccal and labial surfaces of the plates.

While the correct operation of the muscular activities concerned in the expressive movements in which the mouth participates, is largely provided for, if the dentures answer other requirements imposed upon them, it is necessary to call attention to the features of the dentures directly concerned in this relationship, in order that in the promotion of other purposes these considerations shall not be infringed upon. As with natural dentures, the lips should be capable of free and easy movement over the teeth and the labial surfaces of the plates. The margins of the dentures and their external contours should not encroach upon the line of action of any of the muscles concerned in these movements. The labial contours of the plates and the teeth should support the lips in those positions which are subsequently discussed as proper for the establishment of the fixed expressions of the face. They should permit an easy gliding of the lips over them upon the contraction of the various muscles centering in the orbicularis oris.

The upper plate is the one mostly concerned in this relationship. Its upper margin should not impinge upon the attachments of the orbicularis oris in the incisive fossæ. At the position of the canine tooth there should be enough of a prominence to afford a *point d'appui* for the muscles elevating and retracting the corner of the mouth. The upper margin of the plate should not be so thick as to prevent a direct line of action in the elevation of the lip by the levator labii superioris alæque nasi and the levator labii superioris proprius.

The lower denture should avoid in its anterior margin the line of action of the levator labii inferioris, which is placed to the side of the median line of the symphysis.

An incorrect relation between the jaws would, of course, cause a limitation of these movements, if the distance established were too great or too small, and too great or too little prominence to the plates underlying the lips would cause a similar limitation to the expressive movements of the mouth. It will, of course, be seen that the conditions necessary for the correct operation of the movements concerned in expression, have been provided for by other considerations relative to the dentures. These several demands have overlapped in this particular and the necessity for the correct construction of the dentures is, therefore, increased.

IV. THE RESTORATION OF FACIAL EXPRESSION.

The alteration in facial expression which succeeds the loss of the teeth has been described in Chapter I. One of the chief functions of artificial dentures is to restore this. By the insertion of artificial dentures the relation between the jaws should be correctly established, the contours of the lips and cheeks restored, and the teeth and those portions of the gums visible in the movements of the lips restored as nearly as possible to their original appearance. The various steps in the design and construction of the dentures which have already been described have served to promote these ends.

The relation between the jaws in the position of occlusion is established when the bite is taken. At this time also a tentative fulness which the plates should possess to restore the lips and cheeks to their original contours, is obtained. In the arrangement of the artificial teeth, the portions of the dentures visible in laughing and smiling are arranged so that the teeth correctly harmonize with the other features of the face. The court of final resort in determining the efficacy of these several measures should be the actual trial of the dentures in the mouth. It is now proposed to discuss the various details of the dentures which are related to the restoration of facial expression.

The primary object which artificial dentures should have from the cosmetic standpoint is the establishment of the appearance which the patient would have if the natural teeth had remained. This is, of course, however, subject to the slight exceptions which have already been mentioned in this chapter, but in the main, this is the purpose in view. It has aready been shown that complete data for the execution of this motive are lacking in nearly every instance. The circumstances most favorable for the exact establishment of such a condition are the recent extraction and preservation of the teeth of the patient for reference, and the possession of photographs taken shortly before the teeth were lost. Even to these data must be added an allowance for the effects ensuing, if an appreciable period has elasped between the restoration and the time to which the original data referred.

For the most part the restoration of appearance must be undertaken with data secured at the time the dentures are made, which are the only source of reference. These data are to be obtained almost solely from the patient. They may be occasionally supplemented by reference to other members of the family of the patient, whose physical similarity so corresponds as to make their use of service. A brother or sister, for example, or a son or daughter, may sometimes be possessed of characteristics resembling those of the lost tissues of the patient which will furnish reliable information in these particulars. The accuracy of this resemblance should be positively ascertained before it is utilized for this purpose. Some general considerations relating to the restoration of facial expression may not be out of place.

While the majority of faces which require restoration by prosthetic means cannot by any artifice be made to correspond to the regular conditions of profile and contour established by the ideals of art, yet these latter should be a possible goal, nearness of approach to which is only limited by the particular conditions found in the individual case. The attainment of this ideal is neither to be hoped for nor expected, because of the natural limitations which the conditions of each case impose. In the lack of definite information as to the conditions originally existent in the individual case, the effort should be to exhaust the information furnished by the tissues as to the original condition, and then to complete the restoration along lines consistent with the artistic ideals.

The student will find the following quotation from John W. Vanderpoel's "Drawing and Construction of the Human Figure"[1] of value in arranging the contours of the lips, and should read it in connection with Figs. 201 and 208, which illustrate a patient with correct facial contours established by a full upper and lower denture. He says, "Beginning with the front view, note the convexity of the mass of the mouth as affected by the teeth; this means that as the corners are farther back than the middle, the curvature of both lips in their approach to the corners partakes of foreshortening. Irrespective of the view, establish the relation of the corners to the middle. This is exceedingly important, as it relates to symmetry in its construction and action, as well as to expression and character. In a normal mouth the corners are slightly lower than the middle. Though the mouth is convex in the mass (except at the corners where the lips dip into a depression), it is differently expressed in each lip. The mucous portion of the upper lip is divided into two equal parts or planes, of greatest width in the middle, retreating in diminishing thickness with a downward course to the depressed corners. The lower lip on the other hand contains three planes, the central one extending well on each side of the middle of the upper lip, and flanked by a minor one on each side, rising to an acute angle at the corner. The planes of the upper lip are comparatively flat, while those of the lower are very convex.

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[1] The Sketch Book, July, 1903, p. 25.

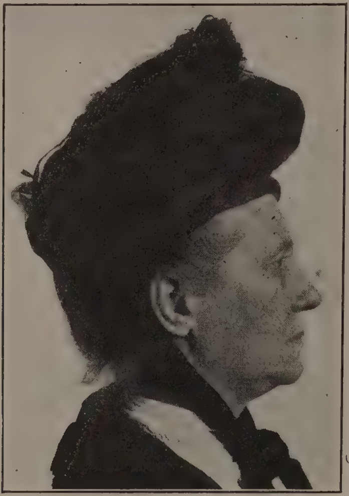

Fig. 201.—Profile view of correct facial contours established with artificial denture.

"The length of the upper lip has its origin at the middle cartilage of the nose in the form of a depression, which widens as it descends, and terminates in the delicate angle of the middle of the upper lip. The center of this angle forms the most forward part of the mouth. This angle is repeated in the contact of the upper lip with the lower immediately below this point, although the angle is more obtuse and a little flattened, showing how the upper lip clasps the lower as it overhangs it. The lower lip rolls outward and is apt to be full and convex in proportion as the concavity below it is deep. This depression or length of the lower lip divides perceptibly and forms at its base the upper border of the chin. Through a study of the profile, which is equivalent to the section, these facts are more easily understood. Note first the backward sloping plane from the nose to the base of the chin, and in it find a series of steps, the upper lip overhanging the lower, and the lower the chin. Note the concavity in the length of both lips, and the convexity of their breadth or mucous portion, greater in the lower—at least more rolling—all subtly connected with the adjacent parts of the face, particularly in the soft play at the corners. . . . However, the student must fully realize that no matter how intimate his knowledge of a part may be, it is only of value when it coëxists with an appreciation of its relation to the entire structure."

The regular profile above described is that obtaining only with individuals the antero-posterior relation of whose jaws produces it. As the prosthetist has no control over the antero-posterior position of the mandible in his restorations, it is only in the cases in which this is normal that he may attempt to establish the relation of the lips which is shown to be harmonious with such a jaw relationship. He should take note, however, of the commonly observed principle of profile that a projection of the lips, which is caused by a projection of teeth and process, is commonly associated with a receding forehead, and that in those individuals possessed of a more marked development of the frontal region in which the facial angles more nearly approximate 90 degrees, there is less protrusion of the lips.

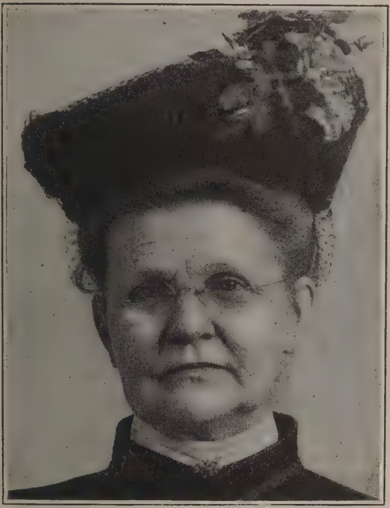

Fig. 202.—Front view of patient with full upper and lower artificial dentures in place, showing restoration of facial contours. Same patient as in Figs. 53 and 54.

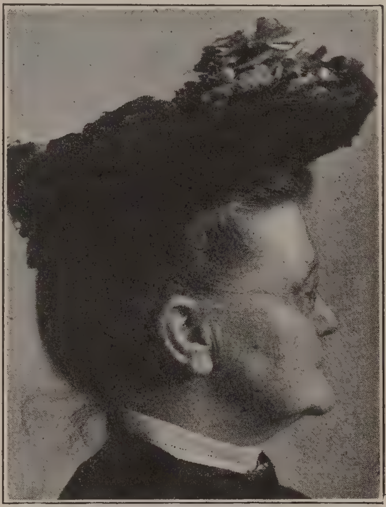

Fig. 203.—Profile view of patient showing restoration of facial profile. Same patient as in Figs. 53 and 54.

The conditions of contour of the lips affecting the profile commonly observed in individuals with the jaw anterior or posterior to the above described relationship, should be observed. A common type of face observed is that with a retruded chin. In these cases the positions of the lips are altered from that above described to accord with such a position of the mandible. This type of face is shown in Fig. 205. It will be seen by reference to this figure that the lips occupy approximately the same relation with a line drawn from the base of the nose to the chin as they occupy in Fig. 201. In all cases where the jaw occupies this position this relation of the lips should be obtained. The upper lip must frequently be made slightly more prominent, but this only to be done when the contours of the alveolar processes demand it. (Figs. 204 and 205.)

Cases are of less frequent occurrence in which the mandible is protruded. In an edentulous case of this character, beside the observed relationship between the alveolar processes, the prominence of the cheek over the ramus of the jaw contributes to aid in the diagnosis. In such instances the curves of the lips observed in cases with a normal jaw relationship do not exist. This is because of the nature of the support afforded the lips by the process and the differently inclined teeth and because of the muscular action which has been necessary to keep the lips closed. In such instances, therefore, the prosthetist can only, of course, hope to establish conditions of profile which were as good as those existing before the loss of the teeth.

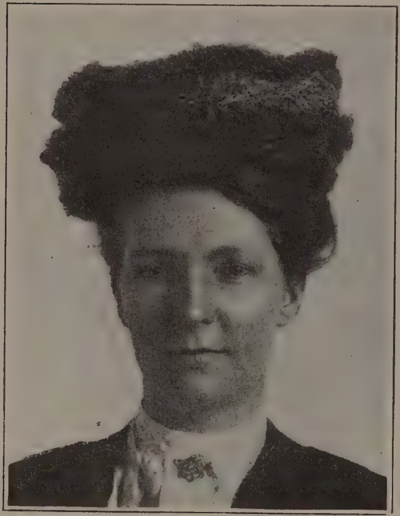

Fig. 204.—Front view of patient with full upper denture in place, showing restoration of facial contours.

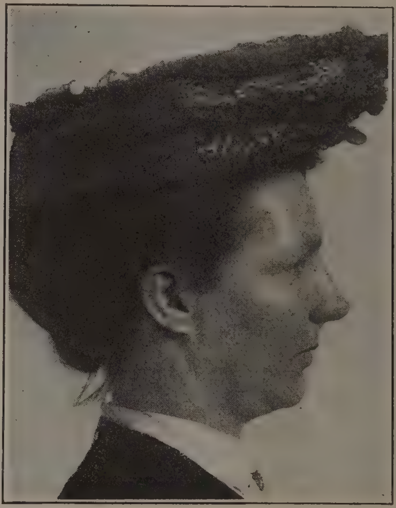

Fig. 205.—Profile view of patient with retruded chin; full upper artificial denture in place.

At the age at which artificial dentures are commonly necessary, the full and rounded contours characteristic of youth have usually faded. In individuals of this age who have not lost their teeth, these effects are likewise observable. The prosthetist, therefore, should take into account in his restorations the effect which age produces upon both profile and contours, and should establish these in accordance therewith. A patient exhibiting the effects of the passage of time upon other fixed features of the face, yet displaying oral contours belonging to a previous period of life, would be an inexcusable anomaly.

The effect of age in the absorption of the subcutaneous fat, in the atrophy of the skin, and the establishment of wrinkles in the face, has been described in Chapter I. No attempt, therefore, in the prosthetic restoration should be made to alter the conditions clearly attributable to this influence. The lines about the mouth, for example, which have resulted from age, are not to be altered, while those which have ensued from the loss of the teeth are to be corrected as far as the prosthetist is able.

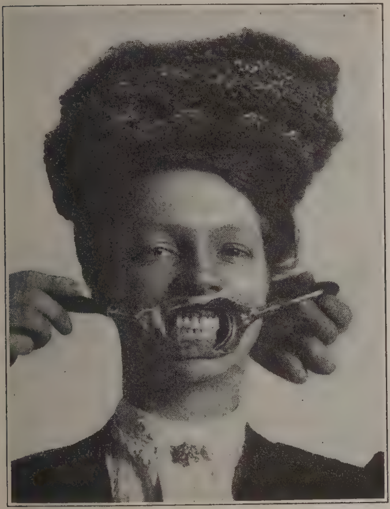

Fig. 206.—Full upper denture with elongate centrals, slightly inclined lingually. Same patient as Figs. 204 and 205.

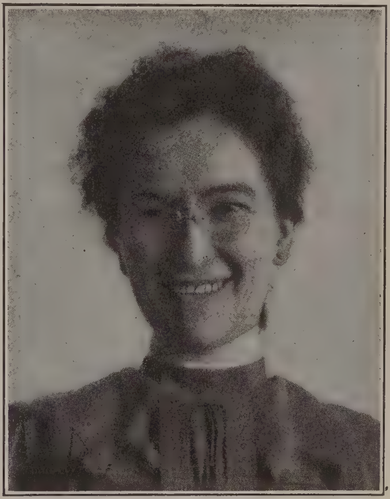

Fig. 207. — Patient with full upper denture: incisors irregularly arranged.

Finally, the prosthetist should utilize every minutia of information to be obtained from the patient and from the conditions of the tissues about the mouth. A full knowledge of the influence of time and of the influence of the loss of the teeth should be in his hands, and his efforts should be directed toward the reëstablishment of conditions, alterations of which have produced the observed changes.

In discussing the details of the restoration of the contours of the mouth and cheeks, simplicity will be consulted by considering first the profile and then the contours of the face as viewed from the front. In establishing the profile in accordance with the principles above outlined the following factors are to be taken into account: First, the relation of the jaws. This is determined tentatively at the time the bite is taken, concerning which it was said, that such a distance should be established between the jaws and such a fulness of the bite-plates provided, that the lips rest in contact without restraint and display an equal amount of mucous membrane. Although the contact of the lips in the manner described as desirable, is influenced both by the distance between the jaws and the fulness of the bite-plates, these two factors should have been so adjusted that the amount of protrusion of the lips desirable in the case in hand is obtained. If this has been satisfactorily done and dentures constructed to accord with the forms of the bite-plates, no alteration in the distance between the jaws will be necessary.

The base of the upper lip, in relation with the nose and the upper part of the face, is fixed. The chin and tissues up to a point opposite the point of reflection of the mucous membrane of the process to the lower lip are also fixed. The amount of outward inclination of the upper lip, its curve, the amount of mucous membrane displayed, the position of the lower lip, as related to the upper, and the sulcus mento-labialis are the factors which may be adjusted. The thickness of the lips is another factor which may be in some part taken as an index of their position, thick lips being usually associated with an outward inclination of the teeth and a projection of the lips, thin lips being usually associated with a less prominent position. For the most part the line from the base of the nose to the margin of the mucous membrane of the upper lip is approximately a straight line. It is curved inward where the margin of the lip is prominent, the curve being due to the difference in thickness of the lip at this point, and not to the conformation of the supporting structures beneath. Where the lower jaw occupies a distal position, the lip may be either in a vertical line, or may be slightly inclined backward.

The sulcus mento-labialis, which imparts considerable beauty to the form of the lower lip, is caused by the greater thickness of the margin of the lower lip, by the contact of the upper anterior teeth with its upper surface which serves to roll it slightly outward, and by the intimacy of attachment of the skin of the chin to the mandible. This curve is to be established, if possible, but where great absorption of the fat has occurred, or in some cases from an original disposition of the parts, this is not possible.

The amount of mucous membrane displayed by the two lips should be equal in cases with a normal relationship of the jaws. In individuals with a retruded lower jaw more of the mucous membrane of the upper lip will be displayed than of the lower. Where the lower jaw is protruded, there is likewise a corresponding difference in amount of membrane visible.

Viewing the face from the front the following points are to be noted: The line marking the point of contact of the two lips. This is affected by the natural configuration of the lips, by the distance between the jaws, and by the amount of projection of the structures supporting the lips. Unfortunately, at the age at which plate dentures are necessary the fine lines characteristic of youth are frequently so altered that the establishment of these lines in their most beautiful form is impossible. Of course the original condition may have been such that this is not possible. The ideal cupid's bow, shown in Fig. 208, is that to be sought in all cases, but ordinarily only a straight line of separation may be obtained. This should preferably occupy a horizontal plane as it does usually in the natural condition, although cases are frequently seen in which the distal ends of the line are at a lower level than the middle. This latter condition may be produced if the jaws have been established too close together. Where it existed originally, of course, no improvement can be made.

The philtrum is frequently obliterated by the falling in of the tissues after the loss of the teeth, if age has not already had this effect. The prosthetist probably has no influence over the formation of this groove other than, if the lips are put upon too great a strain, it may be further obliterated. The same may be said of a prominent tip or tuberculum of the upper lip. Both age and the loss of the teeth serve to straighten the line of separation between the lips and obliterate this prominence, while in those cases in which this effect has not ensued, the tuberculum should be preserved by imposing no great strain upon the lips.

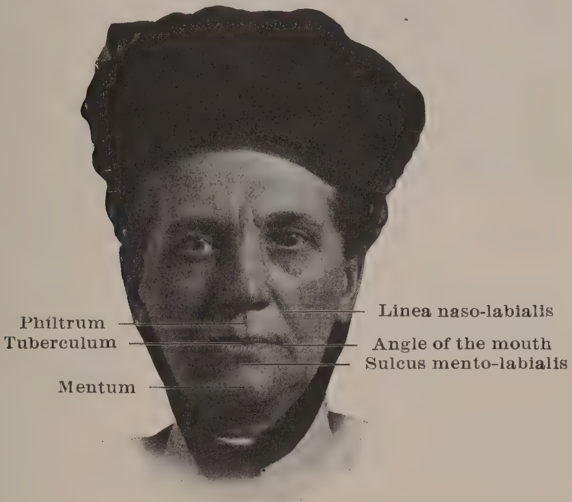

FIG. 208.—Full face, showing good contours and lines.

The canine eminence will usually require considerable restoration with the artificial dentures, because of the large amount of resorption of the process which occurs at its site. The temperamental type of the individal will assist in affording information in determining the amount of building to be undertaken at this point. Individuals of the bilious temperament and its various combinations will require prominent canines and prominent portions of the plate overlying this tooth. In the individual case reference should be made to the naso-labial fold, which is usually accentuated both by age and the loss of the teeth. Ordinarily it extends from the base of the ala of the nose with decreasing depth to a point slightly below the corner of the mouth. The building out of the canine eminence will increase or decrease this fold by elevating the lips to the level of the cheek tissue adjoining the upper margin of the fold. In determining the fulness to be established here, reference should also be made to the already established inclination of the center of the lips.

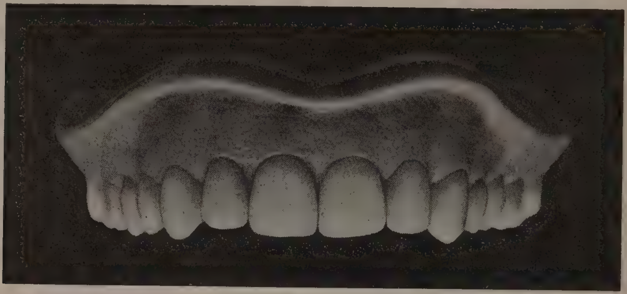

FIG. 209.—Wax model of denture with extensive contours.

In instances in which the wrinkles radiating from the mouth and caused by loss of the teeth have been of long standing it will be impossible to eradicate them by the placing of the denture. Much improvement will occur after the use of dentures properly restoring the contours, but immediate correction of the defects in the surface of the skin cannot be expected. This is also true of the groove frequently observed descending from the angle of the mouth toward the chin, but the plates should remove these wrinkles as far as possible.

CHAPTER VIII.

ESTHETIC CONSIDERATIONS IN THE CONSTRUCTION OF ARTIFICIAL DENTURES.

By NORMAN S. ESSIG, D.D.S.

THE ROLE OF ART IN PROSTHETIC WORK.

The field of art as it pertains to dentistry is an unusual one in many ways. It demands accuracy and truthfulness even to a greater degree than in other departments. It embodies the beautiful in its most artistic form as well as reproduction of the defects of Nature. While the ideal in the organs of mastication and their relation to facial harmony should be the aim of the artistic operator, the reproduction of irregularity and discord, with the effects of accidents and pathological changes is more often his task.

Thus far there is no formula, and after a given point any attempt to classify this work fails of its purpose. The prosthetist, therefore, must regard his subject from a distinctly artistic standpoint in order to make his ideals applicable to his needs, because art means simple, truthful reproduction of natural conditions. It is not, however, a difficult phase of dentistry if the underlying principles and point of attack are firmly established in the mind of the operator in the beginning of his task. There are endless possibilities in this field, the only restriction being the limit of personal attainment in working out scientifically the problem of anatomical and artistic reproduction.

The artistic touches which are necessary in the different cases presented to the prosthetist depend largely upon his own ability and general sense of the appropriate in order that he may see what is needed and make the artistic touches necessary to restore the appearance after it has been marred by the loss of the organs of mastication. Hence, the reproduction of the teeth in the human mouth must include the defects as well as normal conditions if the result is to be truly artistic.

SCIENCE IN PROSTHESIS: BIOLOGICAL, MECHANICAL.

Each patient who wears an artificial denture should have, and is entitled to, the free and untrammeled mandibular movement which is his own individual characteristic in performing his masticatory excursions. It is a composite of all the muscular movements of the wearer in performing the act of mastication. The musculature of the mandible in its function not only reveals the individual characteristics which are of definite scientific and artistic value, but must demonstrate the law of adaptation of organism to function rather than the adaptation of function to organism. This should be a controlling factor in dental prosthesis whatever the relations may be in other departments of biological activity.

From a biological standpoint it is impossible to establish an exact system of classification for the teeth of man, because Nature does not maintain uniformity of standard.

In the study of mechanical science we have for the field of investigation that department which treats of exact measurements and proportions.

Denture making is like other artistic crafts in that the principles which govern its practice should be sound and rational from the mechanical as well as the artistic point of view, nor is it necessary to complicate the application of these principles in denture construction by irrelevant additions to what is absolutely required in the technic of a successful prosthesis.

NATURAL TEETH.

In studying the anatomy of human teeth and their classification we must accept without reserve several scientific facts which have been brought out and established within the last few years by Dr. J. Leon Williams. The result of his investigations revealed conclusively that there are three fundamental types, and as yet nothing has been discovered to show that racial characteristics and environments have in the past done anything to greatly modify these three basal types, so long as men and women married according to tribal and religious laws. It seems reasonable to suppose that the greatest change began when these laws were no longer observed and the various branches of the human race began to intermarry into other races or tribes of distinctly different characteristics. The marriages of today are so heterogeneous that, of all nations, we of the United States have developed greater variation, and have greater recourse to orthodontia as a means of correcting the irregularities.

The three types to which Dr. Williams has been able to trace each variation are determined by the fact that they conform to the parallelogram, the triangle or pyramid, and the rhombus or circle. The diagrams and photographs reproduced in Fig. 210 will show clearly these conformities to their fullest extent, and the order in which they occur:

1. The mesial and distal approximal surfaces approximately parallel.
2. The approximal surfaces converging at the neck and diverging at the cutting edge.
3. Composed of a number of curves conforming to the circle, and is, generally speaking, rhomboidal in character.

It is the purpose to call attention to the fact that all variations from the true type are a composite of at least two fundamental types, and it is indispensable that the typal forms should be recognized and defined so as to classify, not only the crossings or blendings of the true types, but the basal types themselves. Thus being able to determine upon and identify the basic types, it is possible to divide a tooth in halves through its long axis and examine each half separately without reference to the other (Fig. 211). It will be readily seen that the greatest variations in the true type occur in the distal half, the mesial half showing much less variation.

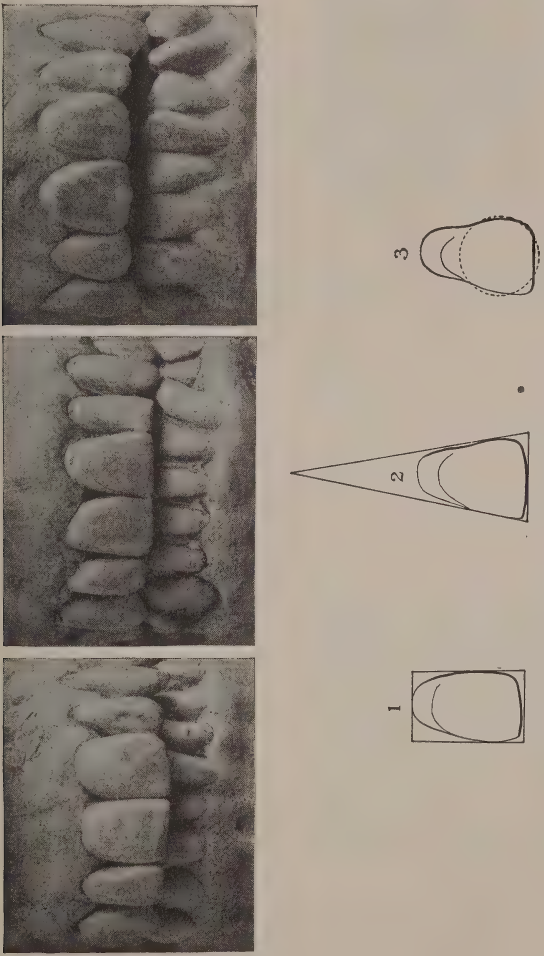

Fig. 210.—The three typal forms taken from record models.

The possible fourth type, which is sometimes mentioned in addition to those more definitely established, resembles more closely the unmodified type of the young adult just at the period of complete eruption. This tooth does not project through the soft tissues fully to the enamel line, and shows no neck whatever but appears to be of a shorter thicker type, having fewer compound curves, although upon extraction it may more closely resemble the other classified types.

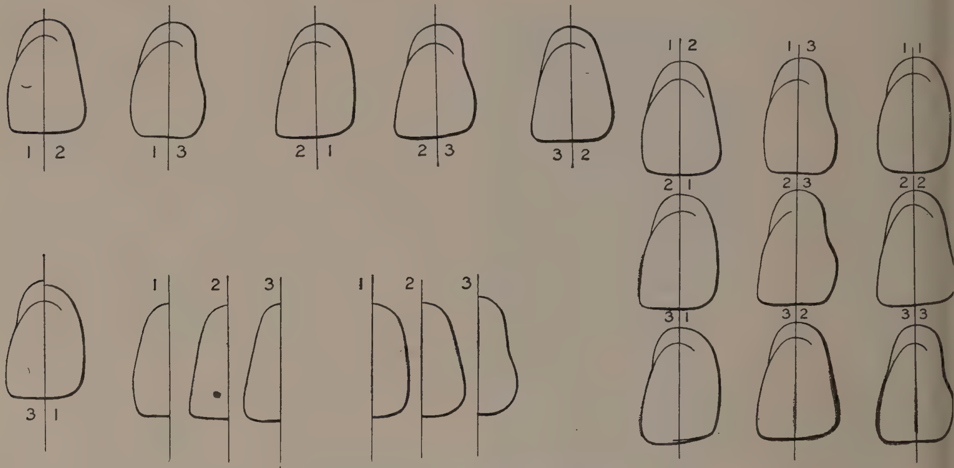

Fig. 211.—Analysis of typal forms.

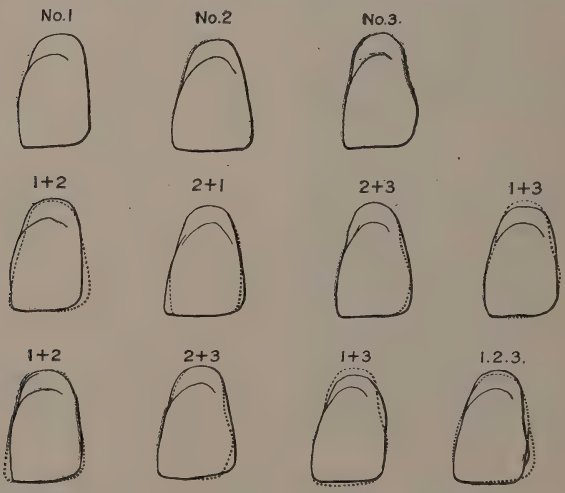

Fig. 212.—Illustrating the manner of superimposing the stock teeth over the templet outline for reforming the teeth.

By the use of a templet accurately conforming to the lines of each type, we are able by tracing one over the other to see clearly their varying curves and the points at which their greatest difference occurs

(Fig. 212). This device should be of immense value to the prosthetist, as it opens the way to special modifications of the true types in the selection of appropriate and harmonious teeth.

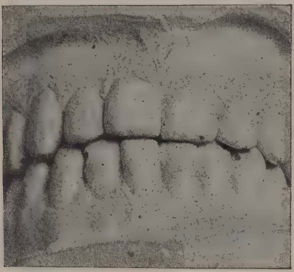

Fig. 213

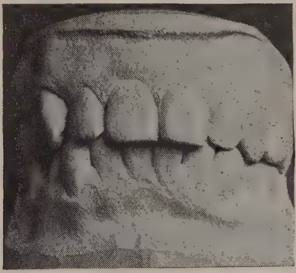

Fig. 214

Figs. 213 and 214.—Illustrations of the fully erupted teeth of young adults which show no effort on the part of Nature toward automatic readjustment or wear, either approximal or occlusal.

Variations.—It will be found upon the examination of a number of mouths that a great variation exists between the teeth of the right and left sides. The apparent balance or symmetry which is found in the teeth of the young adult is more noticeable at that period than at any other time before wear, either approximal or occlusal, begins to manifest itself (Figs. 213 and 214). Later, after these changes take place, the difference in the anatomy of the teeth, when considered in pairs, becomes more marked. Their placement on the ridge has much to do with these variations because it controls and still further modifies the wear (Fig. 215 and 216). The structure of the tooth has not only a bearing on mutilation by wear but is often responsible in this way for the different degrees of modification in its anatomy. Modification may be noticeable upon the facial aspect as well, and eventually becomes more of a pathological change than an anatomical variation.

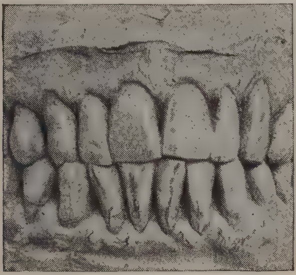

Fig. 215

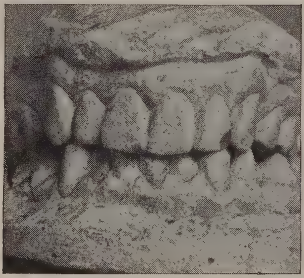

Fig. 216

Figs. 215 and 216.—Illustrations of teeth expressing characteristic identity, approximal wear, and the automatic rearrangement.

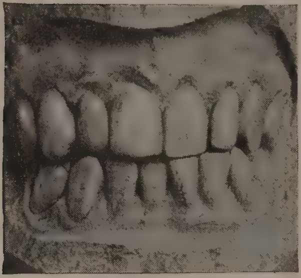

FIG. 217

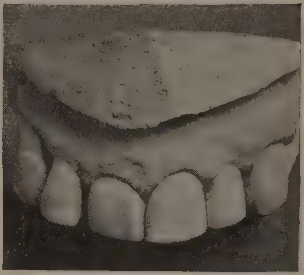

FIG. 218

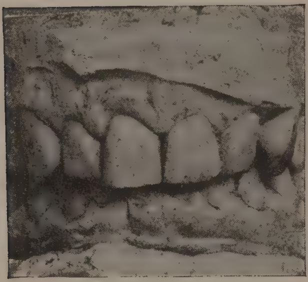

FIG. 219

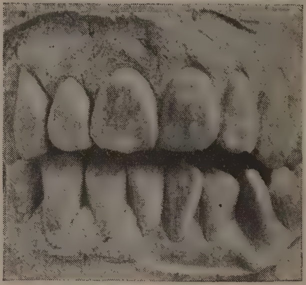

FIG. 220

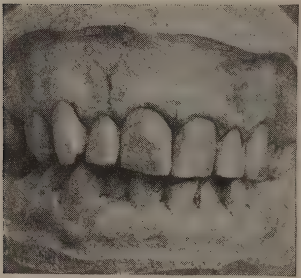

FIG. 221

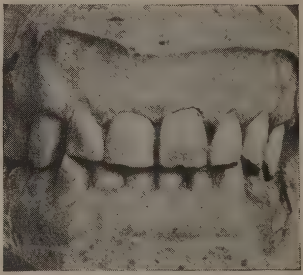

FIG. 222

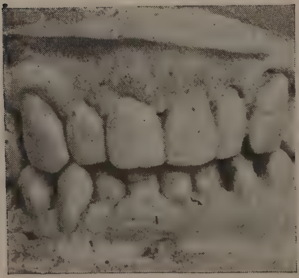

FIG. 223

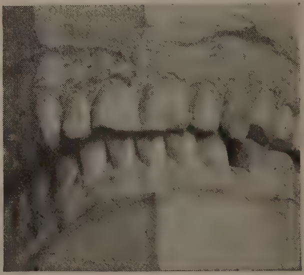

FIG. 224

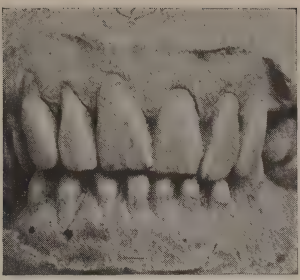

Fig. 225

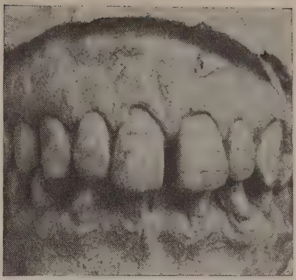

Fig. 226

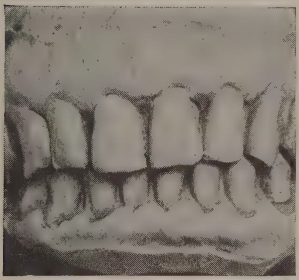

Fig. 227

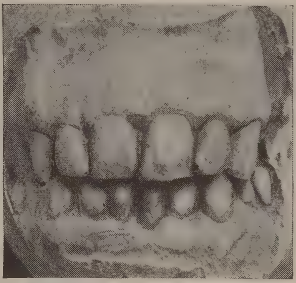

Fig. 228

Figs. 217 to 228.—Lateral incisors which maintain the general type designated by the central incisors.

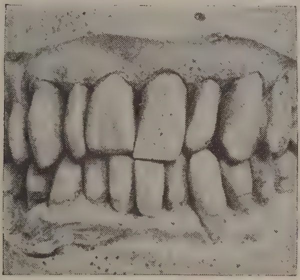

Fig. 229

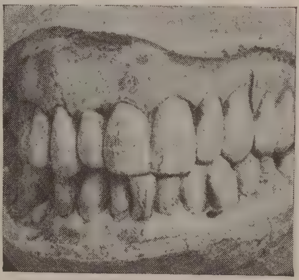

Fig. 230

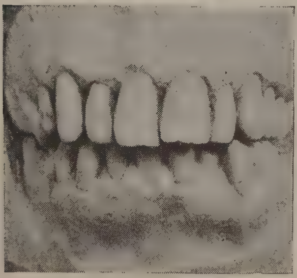

Fig. 231

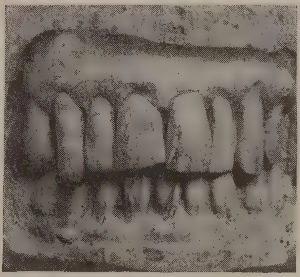

Fig. 232

Figs. 229 to 232.—Arbitrary and characterless forms of the lateral incisors as compared with the type represented by the central incisors.

The operator must thoroughly familiarize himself with mouth conditions, and in order to do this it is necessary to have recourse to data of some sort which may be used as reference. Inasmuch as this cannot be done by literature alone, a collection of record models taken from human mouths, tabulated and filed away with such notations as may be necessary, will be of tremendous assistance. (Figs. 217 to 232.)

Characteristics.—While the teeth of mankind individually are comparatively small, there is a strong and varied characteristic form and alignment, both individually and collectively, in every mouth we see.

The variation in form is often greater than in size, and the difference in natural teeth, as we find them, is a very subtle one especially in teeth of a given type. For instance, the ovoid tooth in the one case may be much larger and narrower than in another, yet it is strictly a tooth abounding in curves, and may be classified absolutely with the ovoid type (Fig. 233). Again an ovoid tooth can be a short, broad one. Its profile may or may not have a curved surface. We often see a tooth whose general outline is ovoid, but which has a comparatively flat labial surface. This holds true in all three basic types and must be borne in mind when a selection of artificial teeth is made with the idea of maintaining harmony with the general outline of the face.

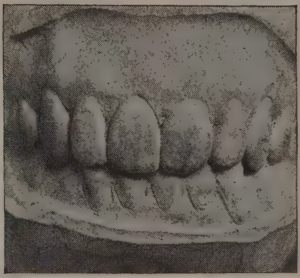

Fig. 233.—Typical example of the ovoid type of teeth.

Varied characteristic appearance is often manifested by the degree of recession which exposes to view much of the dentin at the cervical margin, commonly called the neck of the tooth, so that a short, broad tooth of the ovoid type presents a very different appearance when there is an extensive cervix. This of necessity changes the appearance of the tooth even though the face remains identical and the tooth is not modified by wear.

The lapping of the central incisors often robs the individual tooth of its particular characteristic lines, and the lateral incisors overlapping the centrals has much the same effect upon the disto-proximal position.

The cuspid teeth, which vary in size and form regardless of the incisors, have great bearing on the characteristic alignment. These teeth often bear but little resemblance to the general type and classification of the central and lateral incisors and are most important factors in the characteristic expression of the face. Bicuspids and molars often bear little resemblance to the type expressed by the anterior teeth, and frequently are out of proportion in size.

The six anterior teeth in the lower jaw possess less character, but fall in collectively and aid in giving characteristic expression by their position rather than by their form. When the lower cuspids are prominent, they appear much larger and often change materially the appearance of the mouth.

Color.—We rarely find in natural teeth a variation from the yellow or brown as a fundamental basis for the selection of appropriate color, unless it be influenced by something which has come into direct contact with them. The interference with light transmission, the effects produced chemically or otherwise by filling materials may give the appearance of a digression from these fundamental colors.

There is a shade of a peculiar white appearance, very dense and very strong, frequently found in the mouths of those who have remarkably good health and generally of blond coloring. Upon close examination it will be found that the teeth are not really white, but are a light shade of yellow or brown, growing still lighter at the cutting edges. These teeth are not as prone to decay as those of a deeper yellow color.

The upper central incisors are perhaps the most noticeable of the six anterior teeth, and the shade should be established at that point, the lateral incisiors are sometimes a trifle darker, and the cuspids the darkest, with the yellow shading extending further toward the tip. The bicuspids are usually lighter than the canines, but the shade of the molars is often somewhat broken.

In partial cases where the color is established by the remaining natural teeth, the task is easier because the shade is supplied even if varying to a greater degree than is usually seen in full denture work. Where the anterior teeth and even bicuspids are selected from odd teeth, the effect can be greatly improved by a subtle variation in the shades of the individual teeth.

It is not unusual to find very strong teeth in the mouths of people who are the reverse of robust health, just as it is possible to find teeth that are soft and of poor construction in those having a high order of vitality. Thus it is that the variation in shade is as great and as arbitrary as anything else pertaining to the teeth. The prosthetist must not only rely upon his knowledge of the anatomy and physiology of the teeth to suggest the right shade, but he must be equally well informed from the biological and pathological aspects.

SELECTION OF TEETH FOR EDENTULOUS CASES.

Determining Color.—Color and shade must ever remain a matter of artistic judgment, though a dependable guide may be established by using as a basis of consideration the fact that in youth the teeth are less dense and of a lighter shade, and with each succeeding year the dentin becomes more dense with a deepening of the shade toward a bone-like yellow.

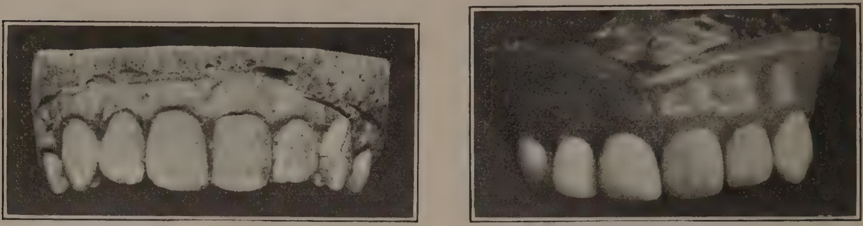

Fig. 234. Fig. 235.

Figs. 234 and 235.—Record model of child (Fig. 234) used in the arrangement of the teeth of the parent.

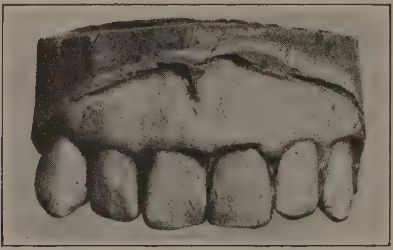

Fig. 236.—Record model taken years before loss of teeth.

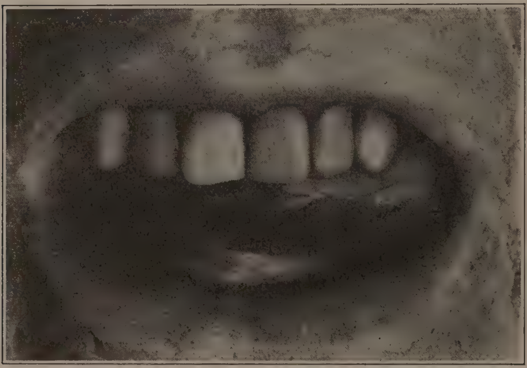

Fig. 237.—Reproduction from record model shown in Fig. 236.

The color of the skin often bears a marked similarity to that of the teeth, especially in the mouths of very young people. We find, however, in the mouths of patients past middle life, where other influences have been at work to modify and change the color of the teeth, that the skin can no longer be taken as a guide.

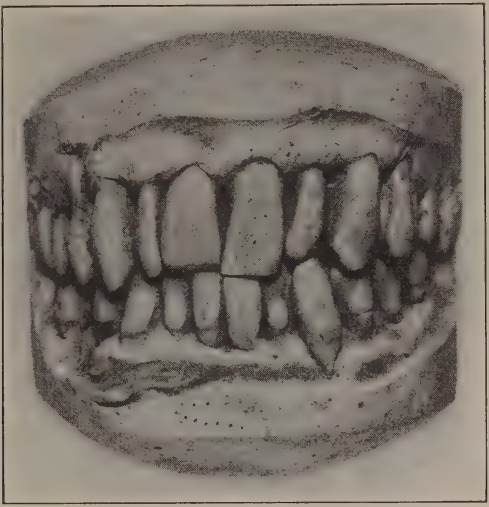

Fig. 238.

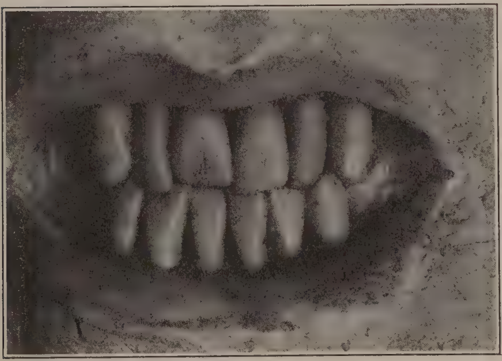

Fig. 239.

Figs. 238 and 239.—Illustrating tremendous advantage of record model previously taken.

Having adopted a rich bone-like yellow, which grades itself into a lighter shade at the cutting edges, as the ideal shade in perfect health, the intermediate variations from it may be used as the basis of our selection, and such gradations as are appropriate to the age of the patient should be determined upon as the case may demand.

REFORMATION OF PORCELAIN TEETH.

In the selection of porcelain teeth from the stock available at our dental depots for the purpose of reforming them to adapt them to special cases, it is well to select the teeth most typical in character with the idea that from these, modifications and crossings can be better produced than from less typical forms. These teeth should be selected from the larger sizes in order that there shall be an abundance of material (Figs. 240 and 241).

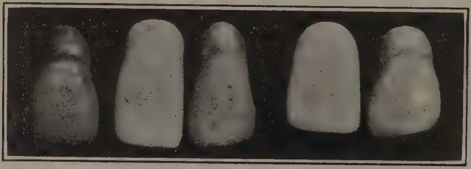

Fig. 240.

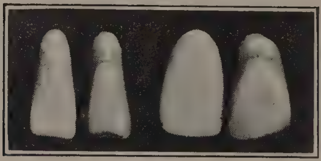

Fig. 241.

Figs. 240 and 241.—Stock porcelain teeth reformed to suit the individual.

Where absolute reformation rather than slight modification is intended, the large conventional molds offer many advantages and should be treated as raw material (Figs. 240, 241). The latter process of course consumes more time, and requires a greater degree of artistic skill than slight modifications at designated points, though in any event we are but drawing with an abrasive wheel.

Many pleasing effects may be obtained by regrinding the large molds, making use of the combination of body and enamel which vary in shade. If the upper half of the face of the tooth is ground off so as to expose the body, which corresponds to the dentin of the natural tooth, leaving the enamel only on the point or cutting edge, very pleasing and unusual effects can be obtained when the tooth is repolished (Fig. 242).

Porcelain teeth as we obtain them from the dental depots represent more truthfully the teeth of young adults than at any other age in the life of man, an age, generally speaking, far removed from the period when dentures or other appliances are required to replace the lost organs of mastication.

A harmonious discord is often induced by the loss of one or more teeth, which in time causes a shifting of those remaining. This produces a change in articulation, causing a marked change in alignment and relation to the opposing teeth as shown in Figs. 238 and 239.

It is advisable to use as far as possible the true basal types and make such modifications as are necessary to produce crossings when they are required; because the greater the variation from the true type in the beginning, the more nondescript the teeth are apt to become when further modified, unless a very large conventional mold be used and infinite skill be employed in a complete restoration.

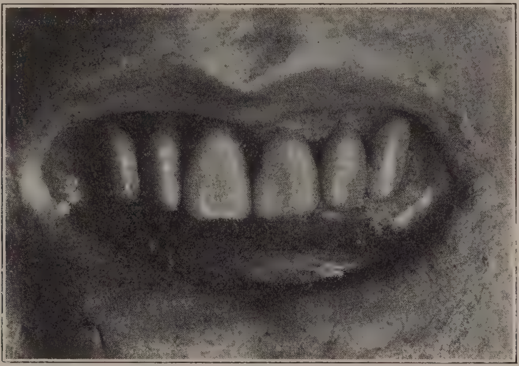

FIG. 242.—Illustrating effect of grinding and refinishing porcelain teeth.

We therefore find that the three basal types, with a robust and typical cuspid, place in our hands every possibility for the exercise of practical skill and artistic ability (Figs. 243 and 244).

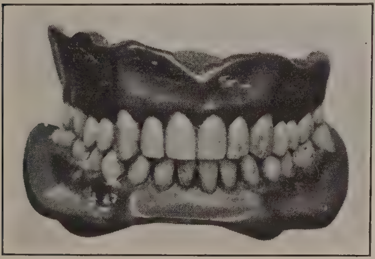

FIG. 243.

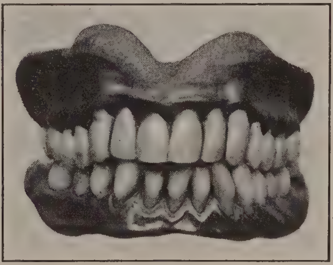

FIG. 244.

FIGS. 243 and 244.—Showing the result of reforming the six anterior teeth from large molds.

Nature abhors a straight line, and has formed the organs of mastication in a combination of the most subtle curves which at once subserve the purpose of strength, efficiency, cleanliness and beauty. It is, therefore, desirable to maintain these lines or curves with the utmost sincerity in artificial teeth, not alone for their hygienic and esthetic features, but because each phase of their construction embodies a definite amount of efficiency and comfort to the wearer of an artificial denture (Fig. 245).

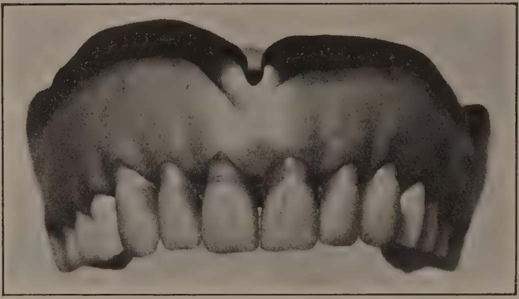

FIG. 245.—Showing reproduction of gum recession and enamel cracks occurring in the natural teeth.

General contour, profile, variation of shade, together with the reproduction of accidents of Nature will tend to accentuate or modify the appearance of the artificial teeth when in the mouth. Nature has made these features so cunningly interdependent that one is absolutely essential to the other, and a change of their relations produces radical transformation or rearrangement of harmonious and artistic identity. Whenever there are natural teeth alongside of which artificial substitutes are to be placed, our opportunity for securing harmony and precision is much greater if we modify the true type of artificial tooth to suit the case (Figs. 246 and 247).

When the patient is edentulous, and there is no model of the natural teeth to guide the operator, modification is necessary in order to produce the required harmonious effects and a reproduction of those accidents of Nature which are so interdependent that the lines individually and collectively fall away, together with that degree of concord whereby no one feature is given undue prominence.

A limited stock of unmodified typal forms is desirable, both from the standpoint of the dentist and the manufacturer, and the more the dentist relies upon his ability to create crossings for special cases, the greater will be the artistic development along these lines. Whatever is done to break up regularity in shade or outline, the improvement will greatly outweigh the effort expended.

It will not be advisable or necessary at all times to change the buccal or labial surfaces of the artificial teeth, because as has been said the modifications which are frequently seen in natural teeth have their greatest variation from the true type expressed upon the approximal surfaces.

Modifications or digressions from type are easily and readily attained by slight grinding at certain definite points, and in this way wonderful effects may be produced by adding porcelain to a tooth at the desired point and later grinding it to suit the case in hand. This porcelain can also be colored by means of mineral stains to make the tooth adequate to the needs of the case.

In the analysis of a tooth prior to reforming it, the use of the templet previously referred to will be found to be most helpful, as it clearly designates the point of attack and accentuates the difference between the porcelain tooth, which is raw material, and the tooth we intend to reproduce, and as experience is gained in producing varied forms and modifications, the task becomes easier.

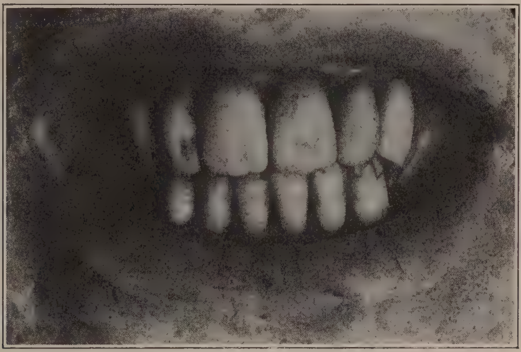

FIG. 246.

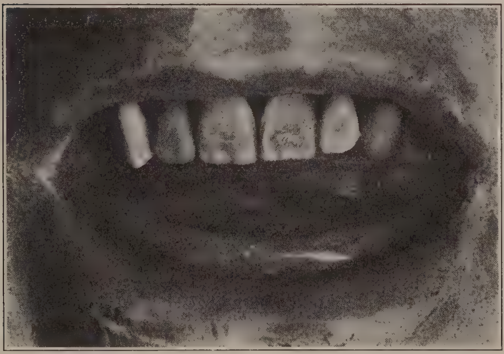

FIG. 247.

FIGS. 246 and 247.—Illustrating the modification of porcelain teeth which are placed alongside of natural ones to secure harmony. The left central and lateral incisors are artificial; the other teeth are natural.

When the operator is fortunate enough to have at his disposal specimens of the true types, he is able to produce much better results with less effort and expenditure of time.

The most vigorous type of cuspid tooth can be refined or modified without changing the dominant lines so as to make it appropriate for use where it is desired to give the impression of refinement or lack of physical force.

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In the arrangement of porcelain teeth for any given case, the operator must remember that the personal touch of the one who comes in direct contact with the patient is at all times necessary, and that by his supervision he must govern and direct the completion of the case, otherwise there will be a lack of character which will result in failure from the artistic standpoint.

Lateral incisors, while often maintaining the same characteristic typal outline as the centrals, are very prone to be arbitrary in their development, and many times bear little or no resemblance to the type represented by the central incisors (Figs. 248 and 249).

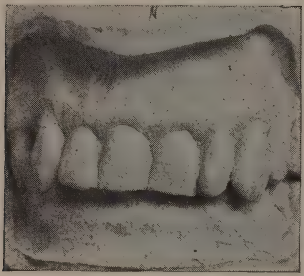

Fig. 248.

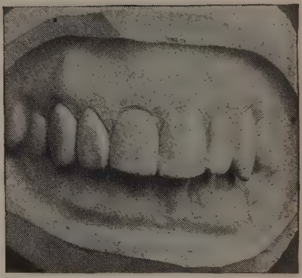

Fig. 249.

Figs. 248 and 249.—Illustrating cases of father and daughter in which the variation is almost identical.

The lateral incisors for the most part occupy only the space allotted to them by the centrals and canines during the period of development before eruption (Figs. 248 and 249). This, of course, is greatly influenced by the bony structure or surrounding integument, and as the entire denture does not erupt simultaneously, it is reasonable to suppose that the great variation is in part due to space arbitrarily allotted to them by the adjoining teeth, both of which are of a stronger and more robust character.

It would seem therefore that the artificial lateral incisor teeth, as we get them from the dealers, are too large in proportion to the central incisors, and in appearance are more like small centrals than the teeth they are supposed to represent. They will, therefore, need more modification to harmonize them with the centrals and cuspids in our effort to impart a life-like appearance to the six anterior teeth.

IMITATION OF WEAR.

Attention should be given to the importance of approximal wear, as many of the so-called crossings or modifications of the true types, as we see them in the mouths of patients of middle age or older, are the result of approximal as well as occlusal wear. This probably accounts for the fact that, while children have what seem to be inappropriate dentures entirely unsuited to their mouths, these teeth often become more harmonious as time goes on and the approximal surfaces come into closer contact.

As the individual grows older approximal wear keeps pace in proportion with the wear caused by mastication and changes the appearance of the original tooth form by obliterating some of its curves.

Strong characteristic, dominant traits acquired by mental or physical habits are usually manifested in some way in the teeth of man, and in most instances make themselves evident to the greatest degree in middle life by the particular way in which wear from use occurs; characteristic effects, either harmonious or otherwise result and the effects so produced become peculiar to the individual by the modification of the form and position of the organs of mastication.

At the stage designated as the first degree of wear, rearrangement generally manifests itself by simple occlusal wear which modifies only the occluding surfaces and incisal edges, but when the second degree of wear is reached the approximal surfaces show attrition, the teeth are further readjusted, causing many times a marked modification in the conditions which were present in the same mouth at a previous period and producing what may be called a harmonious discord.

OCCLUSAL WEAR.

Occlusal wear plays a most important part in the life-like appearance of full denture work. Arbitrary "grinding in" in imitation of wear on cutting edges and occlusal surfaces unless logically done only attracts attention. Wear in the natural teeth only takes place on surfaces that come into direct contact. Mutilation by wear is usually the result of irregularity or loss of teeth, and it is just such conditions that are to be imitated in the artificial denture.

When artificial teeth are set up irregularly they should be "milled in" with abrasive material, not only for the purpose of getting a smooth and regular excursion of the mandible, but also to produce proper modifications on the occlusal surfaces, particularly the cutting edges of the anterior teeth.

If any one tooth in either the upper or lower jaw is given unusual prominence, there should be a corresponding prominence in the tooth which comes directly into contact with it. This tooth in the natural teeth because of its irregularity would undoubtedly become worn to a marked degree, unless due to its irregularity it had pushed the opposing tooth out of alignment, in which case there would still be more wear on the irregular tooth than upon its opponent because its cutting edge presents a smaller surface but travels over a greater surface. Thus we find that the "milling in" is of great service, both in efficiency and in the artistic effect.

STAINING TEETH.

The mere reproduction of form and outline of any given type of teeth is not sufficient to reproduce the denture of an individual case, as there are many times other characteristic markings caused by Nature's process, which may be classified as pathological conditions or surface inequalities due to interference with the normal sequence in the developmental stage. These defects are often made more noticeable as time goes on so that surfaces denuded of enamel, enamel cracks, and imperfections upon the surface are brought into unusual prominence by reason of discoloration, the result of habit or the inevitable deepening of shade as the individual grows older and the tooth structure becomes denser. One of the most common causes for discoloration, however, may be said to be the anatomy of the tooth itself which provides an interdental space intended to be self-cleansing. The bolder portions of the teeth are being continually swept by the lips and cheek, and it is only those portions that are readily cleansed with the brush that are kept perfectly clean; so unless unusual care is taken and the brush is used with skill, the interspaces and those portions of the tooth which are more or less hidden become discolored; this in time has a permanent effect upon the general appearance.

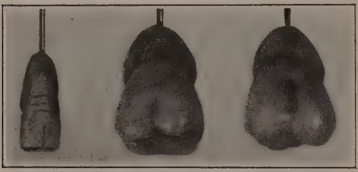

FIG. 250.

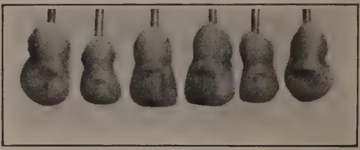

FIG. 251.

FIGS. 250 and 251.—Illustrating reproduction of erosions on the faces of teeth which have caused discoloration.

Accumulation of sordes, tartar, the general condition of the fluids of the mouth, etc., may produce conditions which cause erosion of considerable depth that ultimately changes the surface and color of the face of the tooth, disclosing the yellower dentin underneath. Enamel cracks in the young adult are scarcely visible, but later on become stained by the use of tobacco or other materials taken into the mouth. These cracks often become characteristic markings, and after years form a considerable part of the identity of the individual (Figs. 252 and 253). Therefore, so that where it is necessary to stain the porcelain teeth in imitation of the natural ones, the first logical step is to reproduce the conditions which caused the original discoloration. The enamel cracks may be easily made by cutting thin, hair-like grooves on the faces of the teeth with a fine separating saw or file, after the surface has either been etched by hydrofluoric acid, or the highly glazed surface has been removed by the corundum wheel (Fig. 254).

It is necessary to emphasize the fact at this point that mineral stains or paints used for this purpose will be removed in the course of time by brushing the artificial teeth with the toothbrush if the glazed surface is not first removed. It is therefore necessary before staining to remove such surface caused by the burning of the porcelain tooth so that the coloring pigment applied will sink into the texture of the porcelain and remain fixed. It is also advisable, after reformation or modification of the porcelain tooth, to repolish with sandpaper disks and wood points armed with oxide of tin so that the surface may be partially reglazed by the fusing of the coloring pigment, thus giving a bone-like texture and making further polishing afterward unnecessary.

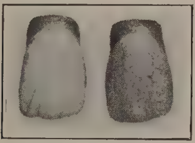

Fig. 252.

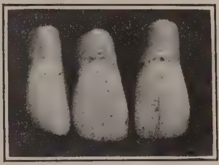

Fig. 253.

Figs. 252 and 253.—Showing reproduction of characteristic discoloration and ename cracks.

Having determined that surfaces reached readily by the lips, cheek and toothbrush are more effectively kept clean because the soft integument continually touches the prominent points, we may imitate characteristic discoloration by the judicious selection of the mineral pigment, and applying it by means of a camel's-hair pencil to the entire surface of the tooth. Then if the finger is passed over the face of the tooth and its surface gently wiped off, it will be found that only the prominent portions and those surfaces which are accessible are cleansed. The coloring pigment will rest in the low spots, enamel cracks and eroded points, and the effect obtained is similar to that which takes place naturally in the mouth. By so doing we have but followed a sequence of events which produced the original discoloration. This does not require unusual artistic skill, and does not necessitate the

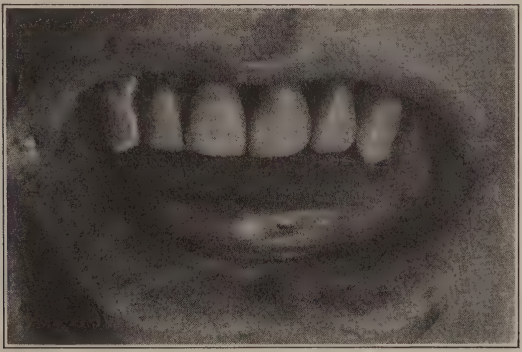

Fig. 254.—Showing reformed teeth with broken surface color.

application of coloring pigment at specific points, except where peculiar facial markings are indicated.

There is often a characteristic cupping out of the incisal edges of the six anterior teeth which in smokers becomes markedly discolored. This often modifies the shade at the cutting edges and may be readily imitated by first making corresponding depressions in the artificial teeth with a disk or stone and filling them with stain, and repeating the wiping movement with the finger which leaves the deep color in the depressions (Figs. 250 and 251). This will have its influence, as in the natural tooth, upon the shade by reason of the fact that it will interfere with the transmission of light through the texture of the porcelain. Light spots may be imitated by grinding a depression at a desired point and restoring the contour by using the low-fusing porcelain. It is often necessary in obtaining the desired shade to fuse the stain more than once, especially if two shades are employed, because it is never desirable to mix mineral stains before applying them. Decorators of china depend largely upon the influence of one shade upon the other when burned separately, because of a tendency of these stains to become muddy if mixed together before they are burned.

Almost all of the manufacturers of porcelain teeth have mineral stains for the purpose, though probably there is nothing better adapted to our purpose than the mineral paints used in the decorating of porcelain-ware or china. These pigments may be obtained from any dealer in artists' materials, and are in tubes similar to other oil colors. These mineral colors are usually mixed with oil of lavender or oil of cloves, and only require that the operator familiarize himself with their use and learn what color to select in order that their application shall give the desired shade when subjected to the heat of the furnace. Gradations of shade may be obtained by using the color strong or by thinning it out by means of the lavender oil. Any of the pigments, however, will turn black for the first two or three minutes before the muffle is brought up to the desired heat, which may be approximately set at 1750° or 1800° F. in any of the ordinary furnaces for baking porcelain inlays. This is also a matter that requires but little practice to obtain uniform results, though it is desirable when possible to use a furnace having a pyrometer. The color if too strong may be subjected to higher heat and thus reduced in intensity, but ordinarily the teeth should be removed from the muffle as soon as the surface becomes glazed. The glaze is never as brilliant as the original surface because the abrasive wheel and polishing media usually produce a more bone-like surface, which is greatly to be preferred, as in the mouth when the tooth is wet with saliva it gives about the same degree of brilliancy as the natural teeth.

No doubt there is a relationship between the color of the teeth and that of the skin and that different factors contribute to determine this coloration, such as racial traits, climate, exposure to elements, etc., hence the skin might naturally be expected to assume a variety of hues, but the internal organs depend on a different factor. Therefore, as the teeth belong in the latter class and are more or less simple and uniform, variation in tint and shade and different degrees of saturation may be the natural result, but the fundamental shade of the teeth is practically the same in all cases.

As we cannot determine just what is the source of the color of dentin, we are not in a position to give a formula for the pigments which enter into the various shades of our artificial teeth. It is, however, safe to state that the basic color is yellow, and the greatest variation from this standard of shade is due largely to the interference of light, which is either transmitted through the tooth structure or is deflected from its surface by reason of the inequalities of the enamel formation. Such variations of surface are responsible, as has already been described, for the staining which takes place automatically upon the natural teeth in the human mouth. Interference in the transmission of light through the tooth structure itself produces various effects and gradations of shade, so that the imitation of the lingual surfaces of natural teeth in porcelain will, if truthfully carried out and the teeth judiciously stained, produce approximately the same results, and, as in the natural process, give the impression of the bluish-gray or green shadings which are ever prone to produce a muddy effect when the effort is made to imitate them in porcelain.

While considering the question of shade, it might be well to remember that no one feature in an esthetic reproduction is sufficient to produce the maximum result, and it is only when the interdependence of tooth form, shade and placement upon the dental arch are carefully observed that we can hope to obtain the highest artistic effect.

Overstaining or the too lavish use of the coloring pigment upon the artificial tooth is worse than though the efforts were bestowed entirely upon the anatomy and alignment without the use of the coloring agent at all. Suggestion both as to color and placement is all that is required to obtain artistic results, or the whole question of the artistic phase may be easily overdone.

It is not desirable to place gold fillings in artificial teeth except when such fillings have been prominent and have become characteristic features of the mouth. If a gold filling is used, the same care should be employed to conceal it as though it were being placed in a natural tooth. Sometimes the suggestion of a cavity may be made on the approximal surface where it is least noticeable. We must remember at all times that the dominant idea in a dental prosthesis is that our work shall not attract attention.

Color or shade is rarely uniform in any mouth; ordinarily the cuspid is the darkest of the six anterior teeth. This, however, may not always be the case in Nature, and when copying natural conditions we must be guided, if our imitation be truthful, by the original conditions if we know them.

CHARACTERISTIC ARRANGEMENT OF ARTIFICIAL TEETH.

There are many characteristic natural arrangements of the human teeth which have already been alluded to and which can be imitated to advantage, the lapping of the lateral or the central incisors (Fig. 239), the reproduction of prominent centrals and retruding laterals, which often gives the appearance of great prominence to the cuspids, the arrangement of the central incisors to reproduce a depressed median line and prominent disto-proximal surfaces; this form of alignment often gives the appearance of very prominent laterals with the cuspids setting well back; these and a host of other peculiarities which have been brought about by an automatic readjustment following the loss of teeth in early life may be used as a guide in setting up the teeth for an artificial denture. The record model is indispensable for this purpose.

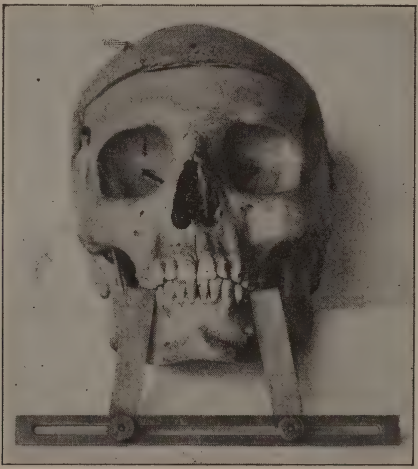

Fig. 255.—Measuring the planes behind the symphysis in order to project the angles.

One of the opportunities for reproducing a life-like appearance which is overlooked in many instances is the arrangement of the cuspid so that its neck at the cervical margin shall be brought into prominence and not depressed (Fig. 245). This does much to restore the facial appearance in view of the flat or veneer-like teeth now in vogue, and especially where there has been great shrinkage of the alveolar process. It tends to give fulness to the lips and the nostrils so that the nose and mouth are not allowed to droop in a manner often most noticeable where artificial dentures are worn.

In constructing an artificial denture the operator should be careful with regard to the profile, and not allow the full-face restoration to absorb his attention to the exclusion of the profile aspect. The operator should bear in mind that the functioning of the mandible is guided and directed by a compensating curve, the center of which is a varying point somewhere in the forehead above the eyebrows, and that the lower arch is generally larger than the upper. This requires that the lower teeth, especially the bicuspids and molars, be tilted in to accommodate the cusp formation on the upper teeth. These facts when taken collectively direct the alignment of the upper and lower teeth in conformity with a triangle or cone which helps us materially in obtaining stability in the denture as well as an esthetic appearance when the denture is in position in the mouth (Figs. 255 and 256). The arc in the curve alluded to is near the base of the cone, and the mandible functionates accurately upon it, and in many instances will establish the proper overbite when the bite-planes are armed with abrasive material such as sand or carborundum powder mixed with plaster.

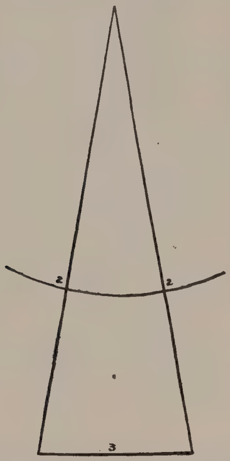

Fig. 256.—Projected angle obtained by the use of the goniometer.

OVERBITE.

Except in rare instances excessive overbite is due to abnormality, and does not enhance efficiency in artificial dentures. The lower artificial teeth should be thick and of generous proportions, and the upper teeth should be full, well rounded, and with a moderate overbite. When the artificial teeth are ground together by means of abrasive material, the lower incisors accommodate themselves to the lingual surfaces of the uppers and *vice versa*. The lower teeth may be cupped out with the carborundum wheel to imitate irregular enamel formation or to imitate characteristic modifications of worn cutting edges. This allows the incisive surfaces to wear just as the natural teeth are worn, bringing two inclined surfaces, the one in the upper and the other in the lower, together, thereby giving the appearance of a much longer overbite, and by reason of the bulk of material in the teeth, adding great strength and efficiency during the incising act. This alone produces a very natural appearance in the mouth, because wear is directed and controlled by the movement of the mandible, and is not merely an imitation of irregular surfaces which are not the result of use.

OCCLUSAL PLANES.

Whenever it becomes necessary to extract a number of teeth before the denture is inserted, and especially if there are teeth in the upper and lower jaws, it is well to make the dentures separately, and to begin in the jaw in which there are the fewest teeth remaining. Thus if the upper jaw has less teeth than the lower, the upper denture should be completed first so that the teeth can be articulated upon those which remain in the lower jaw. In this way characteristic effects produced by the occlusal planes can be preserved. This method pertains only to those cases where there is no deformity, or where the teeth have not changed position, allowing encroachment of the condyle in the region of the ear. Following this, the procedure can be repeated, and the occluding natural teeth in the lower jaw may be extracted after the upper denture is completed.

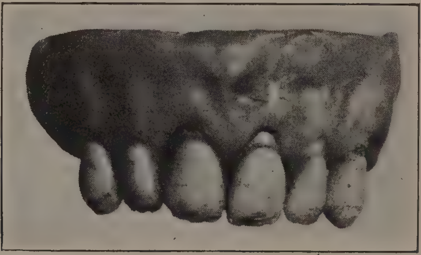

FIG. 257.—Illustrating the reproduction of defects in the enamel edges along the occlusal plane.

In a large majority of instances this method helps the operator to acquire a most artistic replacement of the artificial teeth upon the respective dental arches. It does not, however, except in few instances where there is no irregularity, give the opportunity for the normal interdigitation and balance of the twenty-eight artificial teeth. If artificial teeth are ideally placed upon the ridge, the appearance is very often too set and regular, and is entirely inappropriate in the mouths of elderly people.

As we are often called upon to replace accurately such defects in tooth surfaces and alignment as may have been prominently characteristic in a particular mouth through the modification caused by wear, we must do as Nature does and reproduce the effect attained by digression from the ideal or normal (Fig. 257).

To reproduce the average denture of a patient past middle life, the preliminary "setting up" of the artificial substitutes to such occlusal planes as we may decide are advantageous, requires no little grinding to adapt them to each other and produce the desired result. Whatever may be the tendency with regard to the articulation of porcelain teeth, it is often necessary that a certain amount of grinding be done at the necks of the teeth before the teeth can be artistically arranged according to our record or knowledge of original conditions, and also before the dentures are tried in the mouth while upon the temporary base-plate, and before vulcanization. At this point we are not committed to a definite fixation, and slight modification can be made to preserve certain characteristic features, the presence of which we desire to indicate rather by suggestion than otherwise. In this way a mouth having irregularities to the point of deformity may be approximately reproduced and made comparatively regular with only a suggestion of what was originally a marked defect or abnormality.

Interesting results may be obtained in this way, and mouths which have been hitherto almost repulsive can be idealized, and the patient's general appearance greatly improved. This may be as readily accomplished with the individual tooth as in the case of a number of teeth and does not necessitate an embarassing period while the friends and associates reaccustom themselves to what may be a complete change in appearance.

PLUMPERS AND THE COMPENSATION FOR SHRINKAGE OF THE ALVEOLAR RIDGE.

Under ordinary normal conditions where teeth are retained until old age, there is a resorption of the alveolar process and a consequent shrinkage of the soft integument surrounding the teeth. This shrinkage is of course rapid and much more extensive when the teeth are extracted, causing depressions and consequent changes in the facial contour which in turn will produce lines in the lips and cheeks that contribute materially to the appearance of advancing age. A change in the entire expression of the mouth, chin and nose is often brought about. These changes are more or less characteristic, and to the dentist who is observing may be classified.

The loss of the cuspid teeth produces greater change of the expression of the lips, mouth and nose than the loss of the four incisors, and care should be taken when the trial piece is inserted and the teeth set up in wax to definitely locate the canine protuberances, and to carefully note the expression of the mouth, both in full-face view and in profile. The nostrils may be raised slightly or depressed as the case may be. The center line of the lip may also be drawn upward by raising the periphery of the artificial denture, and a severe or firm expression of the lips may be overcome by the use of the so-called plumpers; by which we mean the building out on the buccal surfaces or peripheral edges of the artificial denture at desired points in order to cause the muscles to lift the mouth or the lips to relieve a severe facial expression or to ease the muscles that control expression.

Probably the easiest facial restoration is restoring the contour of the cheeks. If the building out of the plate is extended to the region of the molars, the corners of the mouth can be cunningly raised so that an attractive curve to the lips may be obtained. Care should be taken not to overdo this effect, and carry it to a point where muscular effort is necessary in order to close the lips or to regain a comfortable position. It must be remembered that where an artificial denture is inserted for the first time, the mouth and its tissues, together with all the muscles used in mastication, resent its presence and it is only after the patient becomes tolerant of it and relaxation of the muscles is complete that we can be certain of the effect desired. It, therefore, frequently happens that the work must be modified after the patient has worn the denture for several days.

We may often count upon a certain amount of adjustment being necessitated by the impingement of the denture on the soft tissues, and relief at such points will do much to obtain the required muscular relaxation. In many instances the lip is drawn up at about the median line in the region of the frenum, producing the effect of a short upper lip, and the denture having unusual height at this point may often give the appearance of the teeth being set too low on the ridge, thus exposing too much of their surfaces. Cutting away the periphery of the denture at this point to relieve the frenum will often overcome this difficulty. Mention is only made of this point in order that it may be used to correct expressions where it is desired to shorten the lip.

It may be pertinent at this point to refer to the size of the six anterior teeth, and to advise the use of teeth rather large at the necks, in order to avoid the display of pink rubber in the anterior part of the mouth, it being more desirable to show the porcelain surfaces than the rubber, as the latter, at best, is artificial in color where large surfaces are exposed.

The position and alignment of the anterior teeth demand care and skill to obtain the most desirable effect; and in this way, with the careful addition of rubber at the proper point, lines which appear with advancing years may be obliterated, or at least held in abeyance. Thought and study in this direction will make clear the physiological reason for so-called wrinkles, and the operator can display his skill and judgment to great advantage by restoring the lost tissue which has brought about this condition.

HARMONY.

The cases where ideal harmony exists between the outline of the teeth and the face are rare indeed, and keen disappointment is often experienced in cases where the smile or conversation reveals the organs of mastication. We are, however, often able to anticipate with accuracy the fact that an artificial denture is worn for the reason that, in rare instances where care and skill have been expended to compensate for shrinkage, a peculiar blank expression of the upper lip takes place which apparently influences the position of the nose and lips. This is in a large part due to the failure to properly restore the canine protuberances. The loss of the canine teeth will effect a greater change in the facial appearance than the loss of any other teeth in the dental arch.

To obtain the maximum artistic effect in denture restoration, the teeth should be placed upon the ridge as nearly as possible in the same position as the natural organs. This effect cannot be accomplished when a tooth of a flat character is used, but it can be accomplished by the selection and use of teeth of ample size and proportions. Modifications can then be made to eliminate or produce certain lines which may be desirable in our efforts to create harmony and conformation of profile.

CHAPTER IX.

PARTIAL DENTURES.[1]

BY W. E. CUMMER, D.D.S., F.A.C.D.

PRELIMINARY SURVEY.

- Dental prosthesis (excluding surgical prosthesis)
  - Full dentures, supported by mucosa alone.
  - Bridge dentures (fixed and removable) supported mainly by teeth or roots.
  - Partial dentures, supported mainly by mucosa in conjunction with teeth or roots, or by the mucosa alone.

DENTAL prosthesis divides itself naturally into the three classes, as given above, by reason of the separate and distinct character of the bio-engineering problem associated with both the support (or bearing) and retention (or the securing in the mouth) of each of these classes. As noted in Chapter VI, "The Principles Underlying the Retention of Artificial Dentures," the retention of the full or entire denture type of dental restoration depends, in the upper jaw, largely upon the physical phenomenon of adhesion, supplemented by air pressure in certain phases; and in the lower, the same, considerably modified by special conditions existing in these restorations, and supplemented to a limited extent by gravity. As noted also in Chapter XVI, "The Assembly of United Crowns (Bridgework)," this problem of the design and construction of bridge dentures becomes, as in the sister science of engineering, one of statics, with end abutments and intermediate members supporting a superstructure designed in principle and on somewhat similar lines to the bridge of the engineer, resting upon a substructure of prepared teeth or roots, the latter having in function a similar duty to the prepared substructure of masonry and concrete of the highway or railroad bridge.

With regard to the subdivision of partial dentures, of which is made up the subject matter of this chapter and because the support is in most cases of a composite nature, being derived from both mucosa and root and similar in each respect to the mucosa support of full dentures and the root support of bridge dentures, the problem embraces considerations included in both of the foregoing classes, full and bridge dentures.

Definition, Partial Denture.—A partial denture is a removable appliance, restoring a partial loss of natural teeth and associated tissues and finding its support upon teeth or roots, in conjunction with the mucosa; and its retention by devices attached to two, or occasionally three anchor teeth (teeth used for retention) and including within itself any or all the following: (1) Base. (2) Teeth. (3) Attachment. (4) Retaining devices. (5) Connectors. (6) Occlusal rests.

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[1] The writer wishes to acknowledge the larger part of the accompanying drawings to Dr. H. H. Cummer, Faculty of Dentistry, University of Toronto.

Support.—The bearing or foundation, upon which all prosthetic appliances rest, comprises three classes: (*a*) Root support, as in bridgework, the bridge resting upon prepared teeth or roots; (*b*) mucosa[1] support, the support afforded by the mucous membrane and its substructure, as in full dentures and in certain types of partial dentures; (*c*) combination support, in which both the natural teeth and roots are engaged in carrying the loads to which the appliance is subjected. (Fig. 258.)

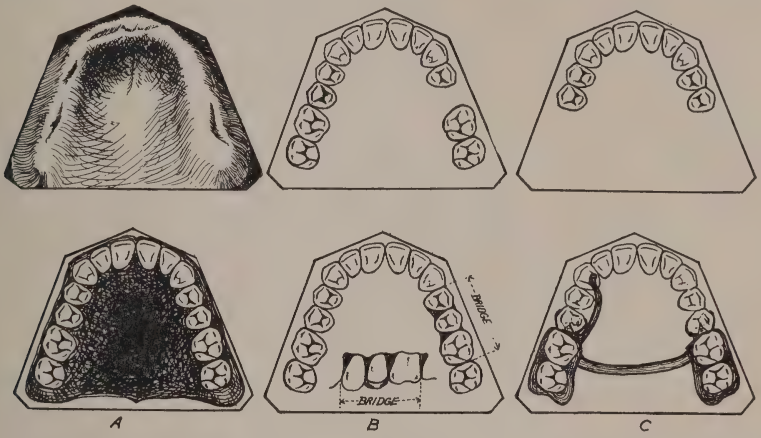

Fig. 258.—*Support.* Examples of dentures, mucosa, root and combination support. *A*, full denture, mucosa support entirely; *B*, bridge denture (fixed), resting on teeth alone; *C*, combination support, an example of a denture resting on a composite mucosa and root support. Note.—Clasps with occlusal rests (three-arm clasps) which transmit loads to the natural teeth and saddles which divide this load with the mucosa.

Retention as Distinguished from Support.—The fixation of the piece in the mouth in such a manner that it is easily removable by the patient for cleansing, yet may be replaced by the patient and retained in the mouth with sufficient firmness and without injury to the remaining structures during mastication, is called Retention. Retention of dentures is of two kinds: (*a*) Direct in which retention is afforded by means of retainers attached directly to anchor teeth (remaining natural teeth or roots) or, as in the case of the full denture, by adhesion, and (*b*) indirect, in which the indirect retainer is applied at a point directly opposite to that part of the denture to be retained. The position of the direct retainers also forms a basis for the classification of partial dentures here proposed.

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[1] Root and mucosa support are convenient terms, designating the structures which first receive the load of mastication, transmitting it in each case to the bone.

The retaining devices in partial denture designs are made to positively engage upon, and readily disengage from, natural teeth, or crowns or bridges built upon natural roots, or upon fittings mounted upon these, usually located diagonally or diametrically opposite to one another, of which usually only two in number are required, occasionally three, very infrequently more. Many varieties of retainers exist, classified as direct, indirect, precision, non-precision, simple and compound. (See Retention Partial Dentures, page 220.)

The intelligent choice, design, location and construction of these retaining devices is probably the feature in partial denture design which more particularly requires direct attention to conditions present, and a careful study of them. Careful consideration in this particular will result in retainers, positive in action, with little or no injury of tooth tissue, either present or future; while, on the other hand, as the writer will shortly undertake to point out, a bad design in this or in other respects, especially when coupled with an inaccurate and careless construction, will result in an appliance seriously destructive to the remaining tissues.

The Object of these Studies.—The various methods subsequently described, which have been almost altogether chosen from the practice of both today and yesterday, have been correlated into a system by which it has been the sincere effort of the writer to secure in part:

A. For the health of the oral cavity.
    1. Greatest possible conservation of tooth tissue.
        (*a*) By minimizing as far as possible the cutting of tooth tissue.
        (*b*) By non-interference with gingival, or other oral parts, which, under periodic professional observation, and with ordinary precautions, should insure immunity from caries or periodontal disease from this source.
    2. Skeleton design, leaving uncovered as much of the mucosa as possible where indicated.

B. For the comfort and convenience of the patient.
    1. Minimum bulk of appliance consistent with masticating efficiency.
    2. Minimum cost, therefore available for a larger number of patients.
    3. Ease of cleansing, both of remaining teeth and artificial denture.
    4. Ease of adding artificial teeth to replace natural ones which may be unavoidably lost subsequent to the fitting of the restoration.

C. For the attending dentist.
    1. Minimum cutting of tooth tissue, minimum chair-time, service for larger clientele.

2. Definite and simple system readily adaptable to all combinations of teeth missing and present.
3. System to be within the handicraft of the average dentist serving the average clientele.
4. System to be within the handicraft of the average laboratory assistants serving the average dentist.
5. The utilization as far as possible of stock materials, equipment and appliances.

THE SCIENCE OF PARTIAL DENTURE SERVICE.

Divisions of Partial Denture Service.—Partial denture service includes (*a*) the science (theory) or classified knowledge, and (*b*) the practice or the actual work, which is governed by the science.

Similarity between the Science and Practice of Prosthetic Dentistry (Notably Partial Denture Service) and of Engineering, Using a Problem in Architecture as an Example of the Latter.—Dentistry is essentially a health service, with a science and a practice.

To its science, in addition to that which is purely dental in its origin and use, great elder sister professions have generously contributed, namely, medicine, surgery, the fine arts and engineering.

To its practice, in addition to that which is purely dental, and also in addition to a technology which belongs to the foregoing sister professions, the crafts of many callings, such as, for example, that of the jeweller, gold and silversmith, ceramist, die sinker, molder, sheet metal workers, have contributed generously.

A striking example of the similarity between that branch of engineering dealing with fabricated structures, and a branch of dentistry also dealing with fabricated structures, although at opposite poles in point of magnitude, may be observed in the following scheme.

1. PRELIMINARY.

Architecture.	*Prosthetic Dentistry.*
(*a*) Preliminary survey of site, foundation available and surroundings; and the collection and study of all facts which bear upon the requirements of the future building.	(*a*) Examination, general (if required and by physician) and oral, of the patient, and collection and study of all facts bearing upon the requirements of the future restoration.
(*b*) Choice of general type of building.	(*b*) Choice of appliance, full, partial or crown-bridge restoration.

2. Design.

(*a*) Complete set of blueprints of the proposed building and its foundation and occasionally a model of the proposed building.	(*a*) A mental picture, or actual drawing of the proposed restoration, and its foundation, often preceded by a study model.
(*b*) Written or printed specifications as to labor and materials.	(*b*) Verbal or written specifications, if the coöperation of laboratory assistants is required.

3. Construction.

(*a*) Excavation, foundation, erection, decoration and finishing of the building.	(*a*) Impressions, casts, bases, articulation of teeth (function and esthetics), further construction, finishing.

4. Installation.

(*a*) Work involved in making the building ready for occupancy.	(*a*) Insertion of denture, and work involved (as spot grinding, lapping, or rebasing), until the service is finished.

4. Maintenance and Repair.

(*a*) As required in the building.	(*a*) As required in keeping the appliance in good condition and the adjacent tissues healthy.

Two Differences Between the Two.—In addition to the difference in magnitude, prosthetic service is governed by the biological laws which apply to the living parts which coördinate with, or are affected in any sense by, the artificial substitutes; a condition not ordinarily present in engineering problems.

Division of the Science of Partial Denture Service.—For convenience in study, the division of the science of partial denture service into three main divisions will here be followed. As noted in Charts 1, 2 and 3 these are as follows:

(*a*) Restoration.
(*b*) Standardized parts.
(*c*) Prevention.

- Partial Denture Service
  - A. Science
    - (*a*) Restoration
    - (*b*) Standard parts
    - (*c*) Prevention
      - 1. Bone.
      - 2. Attachment.
      - 3. Teeth.
      - 4. Retainers.
      - 5. Connectors.
      - 6. Occlusal rests.
  - B. Practice
    - (*a*) Preliminary examination.
    - (*b*) Design.
    - (*c*) Construction.
    - (*d*) Installation or Insertion.
    - (*e*) Maintenance and Repair.

Chart 1.—General scheme of partial denture service detailed in Chart 2, Chart 3 and Chart 8.

PARTIAL DENTURE SERVICE.

Science of Partial Denture Service (a Working Knowledge of).

A. Restoration.

1. Structures to be restored
    1. Teeth.
    2. Associate parts.
2. Functions to be restored
    1. First step in digestion
        1. Mastication.
        2. Insalivation.
        3. Deglutition.
    2. Speech and voice.
    3. Expression.

B. Standardized parts, which, in proper assembly, will:

3. *Restore* structure and function as may be by human agencies
4. *Prevent* further injuries to structure and function as may be by human agencies

See Chart 3.

C. Prevention.

5. Injuries as result of *loss of natural teeth* preventable by proper restoration
    1. Drifting.
    2. Exfoliation.
    3. Excessive stress and wear.
    4. Stagnation.
6. Injuries as result of *faulty appliances* preventable by proper restoration

    Structures.

    1. Enamel, dentin and cementum: intensive caries production, erosion and wear, from capillarity.
    2. Gingivæ: impingement and interference.
    3. Mucosa and subjacent bone: overload.
    4. " " " " strangulation.
    5. Pericementum and mucosa, with subjacent bone: overload.
    6. Pericementum and subjacent bone: overload.
    7. " torque, vertical.
    8. " torque, horizontal.
    9. " inclined plane (wedge), mesio-distal.
    10. " inclined plane, bucco-lingual.
    11. " inclined plane, M.D. B.L.
    12. " inclined plane, axial.
    13. " lever 1st class (shears).
    14. " " 2d " (nut cracker).
    15. " " 3d " (flask tongs).
    16. Pericementum and subjacent bone, combinations of all mechanical advantages.
    17. Dental pulp and periapical tissues, various injuries.
    18. Cheeks, tongue and soft tissues, impingement and irritation leading possibly to malignancy.

    Functions.

    19. Mastication and ultimate digestion, various injuries.
    20. Speech and voice, lisping, thick speech, etc.
    21. Hearing, interference with.

    Both structures and functions.

    22. Any or all of above injuries, from lack of systematic maintenance or other causes.

CHART 2.—The arrangement of the science (theory) of partial denture service is followed in text. The second division (*b*), standardized parts, is continued in Chart 3.

The Restoration of Natural Parts.—The restoration of natural parts by means of the artificial processes and materials as now understood necessarily requires a working knowledge, both macroscopic and microscopic, of the structures and functions which are to be restored. Although a reference only must suffice here, the practical importance of this working knowledge is obvious.

PARTIAL DENTURE SERVICE.

Science of Partial Denture Service.—(Concluded).

Standardized Parts (A Working Knowledge, Including Indications and Contraindications.)

1. *Base* (or saddle) with connecting parts
    1. Skeleton
    2. Continuous
    3. Covering upon palate for auxillary adhesion or mucosa support
    4. Combination of above
2. *Attachment*
    1. Gold
    2. Vulcanite or similar
3. *Teeth* (various forms)
    1. For vulcanite attachment or similar
    2. For gold attachment
4. *Retainers* . . . .
5. *Connectors*
    1. Rigid
    2. Flexible
        1. Simple
            1. Grasshopper
            2. Butterfly and other spring types
        2. Compound
            - Dresch, and various other similar devices
6. *Occlusal Rests*
    - Recessed
        1. 14-gauge oblique wire
        2. Casting
    - Surface
        1. Quarter, half, full and multiple occlusal pads
        2. Two-thirds rigid loop, M.D., B.L. and L.A.
        3. M.D., B.L. and L.I. embrasure and other clasps with metal occlusal cone

Retainers (a partial list).

- *Direct retainers*
    - Precision—all compound (chiefly for bridgework)
        1. Ash (and similar).
        2. Chayes (and similar).
        3. Peeso (and similar).
    - Non-precision
        - Simple
            1. Clasps, one-, two- and three-arm clasps.
            2. Crib, single and multiple.
            3. Auxiliary adhesion.
            4. Staple attachment.
        - Compound
            1. Roach attachments and similar.
            2. Stud, single and double.
            3. Ring and stud, single and double.
- *Indirect retainers*
    - Contact only
        - Surface
            1. 14-gauge wire (round).
            2. Cast.
        - Recessed
            1. 14-gauge wire obliquely recessed in inlay or similar.
            2. Cast to fit oblique recess.
    - Carrying stress of mastication
        - Surface
            1. Various occlusal rests and pads, partial half or multiple.
            2. Rigid two-third loop, M.D., B.L. and L.A.
        - Recessed
            1. 14-gauge oblique wire recessed in inlay or similar.
            2. Casting obliquely recessed in inlay or similar.

CHART 3.—An arrangement of the more important standard parts, which, chosen and arranged in proper juxtaposition during the process of design of the denture, result in successful partial denture service in its remaining phases.

The Standardized Parts.—Differing from the standard parts which enter into the construction of such mechanisms as watches, automobiles, etc., which are actual and are brought into juxtaposition by manufacturing methods in assembling, the standard parts in partial denture service are to a large extent a mental picture of these parts. During the process of designing a partial denture, whether it is done mentally, or on paper, these parts are brought into mental or graphic juxtaposition in the future appliance. For convenience six divisions are used, with suitable subdivisions, which may be noted. (Chart 3.)

The Base.—The base is that part of the denture which comes in direct contact with the mucosa and is both of skeleton design, consisting of saddles of metal joined by small elliptical, half round, or round bars, of suitable form and location, or saddles of vulcanite joined together also by small elliptical, half-round or round bars of suitable size, material and location (Fig. 259, *B*), or of non-skeleton design (consisting of one continuous saddle of gold or vulcanite) in which a larger area of mucosa support is desired (Fig. 259, *C*).

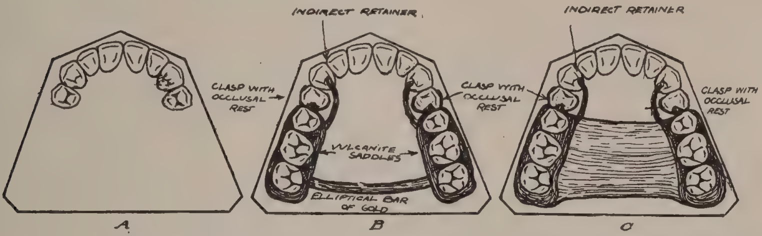

FIG. 259.—Skeleton and non-skeleton bases. *A*, before treatment; *B*, diagrammatic representation of a frequently used skeleton design, the base of which is composite, and is made up of individual vulcanite saddles joined by a single bar of elliptical section; *C*, the same design which for such reasons as a soft type of mucosa, coupled with a heavy occlusion, is constructed in one continuous base of gold or vulcanite.

For cases in which individual teeth or small groups of teeth are found in alternation, a special type of base designated as "continuous" is indicated. An example will be found in Square No. 14 (Plate I).

The extension of the upper base to cover the entire vault is done in order, for example, to secure an auxiliary adhesion, to aid direct retention in cases in which few teeth remain and in which a partial denture is desirable. Example may be seen in Squares Nos. 47 and 49 (Plate III).

Attachment.—That part of the denture joining the teeth to the base is called the attachment. Artificial teeth are usually attached by a continuation of the substance of the base vulcanite or by separate attachment thereto (Chart 3).

Metallic bases are attached to teeth by vulcanite attachment (Fig. 260, *D*), and also by the use of porcelain crowns, tube teeth, suitably prepared, etc., and joined to the base by a metallic attachment of cast metal or solder (Fig. 260, *C*).

Teeth.—Artificial teeth are usually of porcelain, occasionally for small spaces they are of cast gold, and occasionally for special esthetic reasons are the natural extracted teeth suitably mounted are used. The latter are usually mounted by attachment with cement in formed gold copes fitted to the base, and joined to it, while porcelain teeth are used for both vulcanite and gold attachment (Fig. 260).

Retainers, Direct and Indirect.—Reference to Chart 3 will indicate a division of retainers into two classes, direct and indirect. The essential difference between direct and indirect retention is that in the former the retention is derived directly from the tooth to which the retainer is applied, while in indirect retention, the retention is applied at a point remote from the tooth to which the indirect retainer is applied. All of the clasps in Fig. 261, *A* are direct retainers, while the extension in Fig. 261, *B* is an indirect retainer. Further treatment of this subject will be found in this chapter.

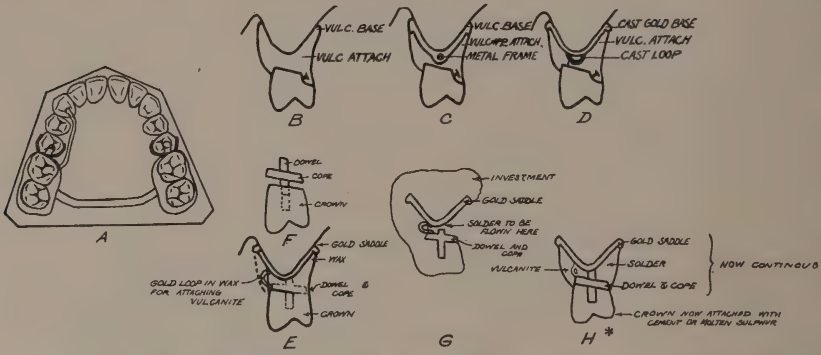

Fig. 260.—Various possible combinations of bases, teeth and attachments, all possible in one design, as in *A*. *A*, diagrammatic representation skeleton design of partial denture as in Fig. 259, *B*; *B*, section of *A* showing composite skeleton base and attachment of with ordinary pin tooth (single vulcanization); *C*, section of *A* showing vulcanite base constructed without teeth, upon which the various steps of "taking the bite" are completed, and posterior teeth are then attached by an additional vulcanization (double vulcanization); *D*, section of *A* showing cast or swaged gold base with cast or soldered loop and finishing edge shows also pin tooth and vulcanite attachment; *E*, stages in making a metal attachment—section of *A* showing swaged or cast base, Ash tube or ready-to-wear porcelain crown tooth with suitable cope fitted to its palatal aspect (see dotted line) and joined to base by gold (cast or soldered) attachment. Natural teeth may be similarly prepared and attached; *F* shows cope and dowel preparation, similar to certain types of bridge section used in *E*; *G* shows cope and dowel preparation invested with saddle ready to solder; *H*, finished piece.*

* Since this drawing was made it has become practical, if desired, to cast the saddle attachment, cope and dowel, as shown in *H*, in one casting. An example of such a casting is seen in Fig. 343.

Definitions, Simple and Compound Direct Retainers.—*Simple Direct Retainers.*—A simple direct retainer is one which makes attachment to a tooth directly without interlocking parts attached to the tooth; for example, various clasps, cribs, etc., involving no cutting of tooth tissues.

Compound Direct Retainers.—A compound direct retainer is one which is made up of two interlocking parts, one attached to the denture, the other to the tooth by means of inlay, crown, bridge or similar device, involving cutting of tooth tissues for reception of the tooth part. For example, the ring and stud, and others.

Precision Direct Retainers.—Precision direct retainers are all compound, and are accurately fitted interlocking parts to ±0.001 inch, and require as a rule accurate "jigs" or guides for settling them in parallel relation. Non-precision direct retainers do not operate under these close limits.

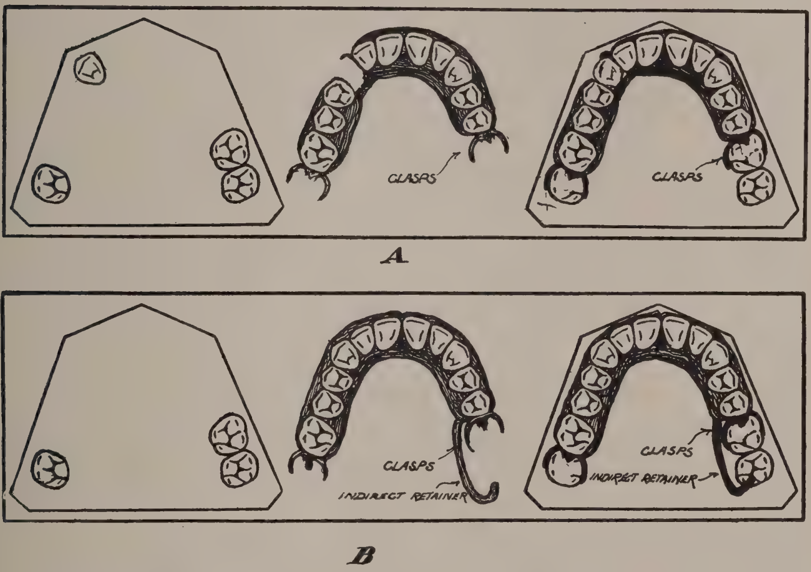

Fig. 261.—Examples of dentures retained, directly and indirectly. *A*, examples of denture retained with direct retainer alone. Note that the clasps are disposed in an approximately triangular relation to one another, as should always be done as far as the position of the anchor teeth will permit, when three teeth are used for retention. Note.—This is also an example of combination support. *B*, example of a denture similar in design to *A*, except that the tooth at the apex of the triangle is not present, and its retentive moment not available. In this and similar cases the design must be modified, and in this instance that part of the denture previously retained directly by the cuspid clasp is now indirectly retained by the indirect retainer acting in conjunction with the direct retainers (the molar clasps) located diametrically opposite to one another. Note.—Another example of combination support.

Because of greater degree of movement, which must be unhampered of partial dentures finding their support partly or wholly upon the mucosa, precision direct retainers find their use more particularly in removable bridgework, and are considered under that head in Chapter XVI. It is therefore not the intention of the writer to attempt to cover this most important point.

Non-precision Simple Retainers.—*Clasps.*—For the reasons already set forth, the misuse of the clasp in past years has caused it to be viewed with considerable distrust by members of the dental profession and even by the laity itself. On the other hand, following simple rules, as for example, of keeping clasp upon the enamel and away from the gingivæ, the clasp becomes the direct retainer adaptable for the greatest number of cases, requiring no cutting of tooth tissue and possessing the excellent features of the larger proportion of the other retainers of all kinds, with the disadvantage of these more or less eliminated.

The writer takes pleasure in quoting in part Dr. Hart J. Goslee of Chicago, teacher, writer and author of the well-known textbook on "Bridgework."[1] "In conclusion permit me to express an honest conviction that, whenever and wherever they may be properly used, well adapted clasps offer in the composite, the most simple, effective, most permanent and sanitary and the least expensive and the least injurious means of fixation of all forms of removable partial dentures."

Clasps. Definition and Classification.—Clasps are simple retainers applied to two or more opposite convex or sloping surfaces of remaining natural teeth, which are chosen for that purpose during the process of design.

For convenience, clasps may be divided into three classes, namely, one-arm, two-arm and three-arm clasps, according to the number of arms or flexible parts of the clasp which are applied to these convex or sloping surfaces.

TWO- AND THREE-ARM CLASPS.

The Two-arm Clasp and its Parts.—The most frequently used type of clasp is the two-arm clasp, the safe application of which is limited to the six posterior teeth. Considering the outline of any of these teeth as approaching that of a circle, the first essential in the design of a two-arm clasp is that it includes three-fourths of this circle as seen in Fig. 262, *B*. It is obvious that a clasp of lesser length would slip off the tooth in a horizontal direction.

Only for purposes of study is the clasp considered as having parts, as in reality it is constructed, as a rule, of a single piece of metal.

Examination of the drawing in Fig. 262, *B* will indicate the division of the two-arm clasp into three parts, namely, two arms and a body, in which the flexible arms of the clasp grasp the opposing convex surfaces of a tooth in a similar manner to which the arms of a man would grasp a similarly shaped object, as for example, a bag of grain, in each case the body being semi-rigid and supplying the foundation for the flexibility of the arm.

The Three-arm Clasp and its Parts.—Examination of the drawing of the three-arm clasp in Fig. 262, *C* will reveal the three-arm clasp to be identical with the two-arm clasp except for the third arm which is one or other of the various types of occlusal rests described later.

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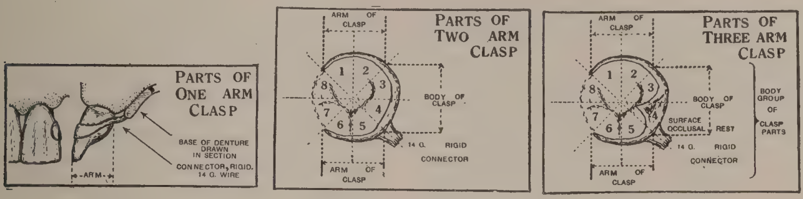
[1] Items of Interest, 1918, p. 191.

Subdivision of Two- and Three-arm Clasps.—These clasps may be subdivided for convenience into (*a*) wrought or cast, according to the treatment of the metal; (*b*) half-round, full round, or band, according to the shape of the metal; three-quarter full or multiple, according to the extent of the clasps; and bucco-lingual, mesio-distal and line-angle, according to the position of the opposing convex surfaces chosen for the application of the arms; finally by special terms based upon the shape of the clasp, as the double clasp, basket, crib, etc.



A *B* *C*

Fig. 262.—Examples of one-arm, two-arm and three-arm clasps, which are described in the text.

Rationale of Clasp Action.—While the rebound or resultant springing of a properly adjusted clasp against the tooth, setting up a friction (or "tenso-friction" as described by Wilson[1]) is all-important in the case of the more unfavorable type of tooth for clasp action, to wit., the parallel-sided tooth, yet the most effective clasps, which go into position with that "snap" so grateful to the patient, are those which mechanically conform to that slight bell or bulbous shape of the crown of that type of tooth particularly well fitted for clasp action. It will be noted that, in order to attach or remove a formed band clasp from such a tooth, its free ends must, in each case, be sprung apart to a distance proportional to the bell shape of the tooth, thus insuring a mechanical locking of the clasp in position.

Type of Tooth Most Suitable for Clasp Action.—Molars, bicuspids and cuspids, in the order named, are the teeth best suited for clasps. Anterior teeth are suitable for one-arm clasps only, provided that they incline toward the anterior, and that there are two other two-arm clasps or similar, disposed in a triangular relation. An example of the latter is seen in Fig. 261, *A*. Peridental conditions must be good and at least two-thirds the normal amount of bone about the root, as shown by radiograms, although as a temporary expedient a tooth with less bone support than this may be used.

Location of Teeth for Clasps.—The general rule for the location of clasps (two- and three-arm) holds good for all direct retainers, namely, considering the upper or lower arches as roughly rhomboid in shape, either diagonally or diametrically opposite to one another, as far as the conditions of the anchor teeth permit.

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[1] Wilson, G. H.: Dental Prosthetics, 4th ed., Philadelphia, Lea & Febiger, p. 348.

This is a matter concerned with the design of the denture, and will be considered under that head.

The Design of Two- and Three-arm Clasps, the Gingivæ and Occlusal Cones, and the Guide Line.—Prothero, in his work on Prosthetic Dentistry, states that "the form of a bicuspid or molar usually represents sections of two more or less regular cones reversed, the bases of which meet in a common plane passing through the greatest bucco-lingual diameter of the tooth."[1] (See Fig. 263.)

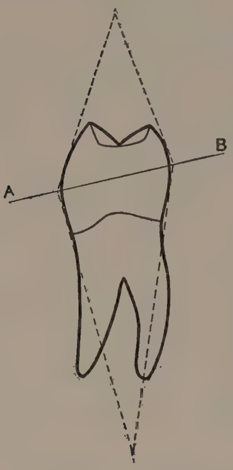

Fig. 263.—Proximate view of a bicuspid, showing the occlusal and gingival cones. (Prothero.)

This meeting place of the occlusal and gingival cones of the clasped tooth represents the position of the summits of the opposing convex surfaces, and will, for convenience, be called the "guide line."[2]

The arms of clasps inserted in the path of insertion would open until they reached the guide line and would close on opposing convex surfaces if carried sufficiently beyond it.

The Path of Insertion and its Selection.—Experience has found that the path of insertion of a partial denture is best chosen as a single direction which is the mean or average of the direction of the long axes of the crowns only, of the two or three teeth to be clasped, in cases in

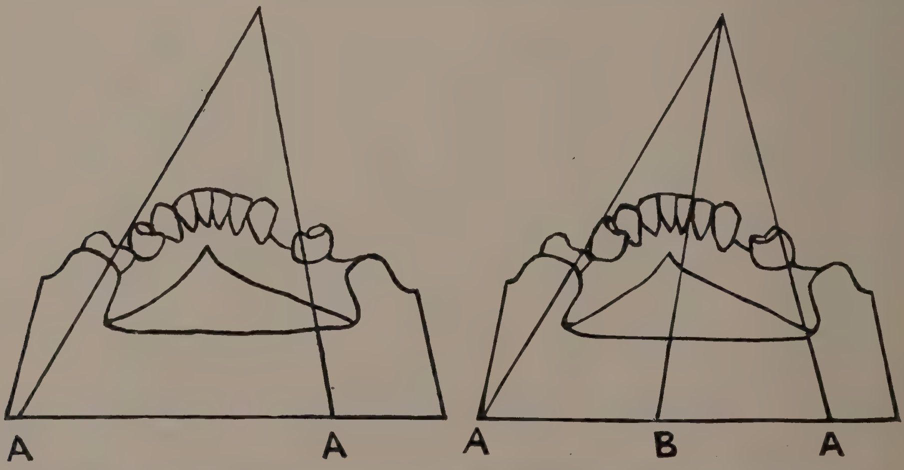

Fig. 264.—The path of insertion is the average of the direction of the long axes of the teeth (*A*) to be clasped. The line *B* represents the average. (Ney Technician.)

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[1] Prothero, J. H.: Prosthetic Dentistry, p. 250.

[2] In addition to a most valuable technic which follows, the writer is most deeply indebted to Mr. George Roth, of J. M. Ney & Co., for a portion of the definitions and nomenclature which follow.

which the denture is supported by the remaining natural teeth. In cases in which the denture is supported by the mucosa, Dr. Walter Chapelle has pointed out that the path of insertion should correspond to the direction in which it is depressed into the compressible mucosa during function. In order to design the clasps of a partial denture, the path of insertion should be chosen before the clasps are designed, because the position of the guide line depends upon the path of insertion. (Fig. 264.)

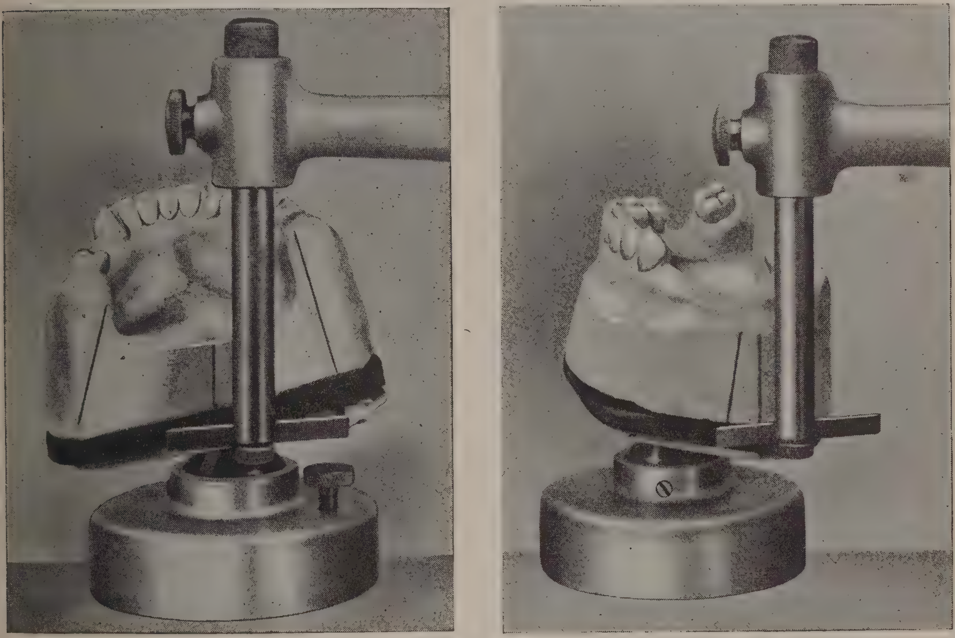

Fig. 265 Fig. 266

Figs. 265 and 266.—Showing the determination of the path of insertion using the Ney surveyor. Two adjustments are made, one at right angles to the other, for the mesiodistal and bucco-lingual slopes of the teeth to be clasped. (Ney Surveyor.)

Determining the Path of Insertion and the Guide Line by the Use of the Surveyor.—The theory and practice of mechanically outlining the guide line upon dental models, has for some years been developed by the Philadelphia Dental Clinic Club, A. J. Fortunati of Boston and others. The instrument and technic bearing the name of the J. M. Ney & Co., Hartford,[1] as developed by Weinstein and Roth, was probably the first to be offered commercially to the dental profession.

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[1] The determination of the path of insertion and the resulting guide line is completely described in a periodical issued by the Ney Company, from which a number of quotations and copies of illustrations are made, called the "Ney Technician."

The Ney surveyor, in addition to the vertical marking member, includes a tilting table to which the cast is attached. This allows the cast, which must be an accurate reproduction of those parts of the remaining teeth covered by the clasps, to be tilted so that the path of insertion is parallel to the vertical marking member. This adjustment may be seen in Figs. 265 and 266, and the actual outlining in Figs. 267 and 268.

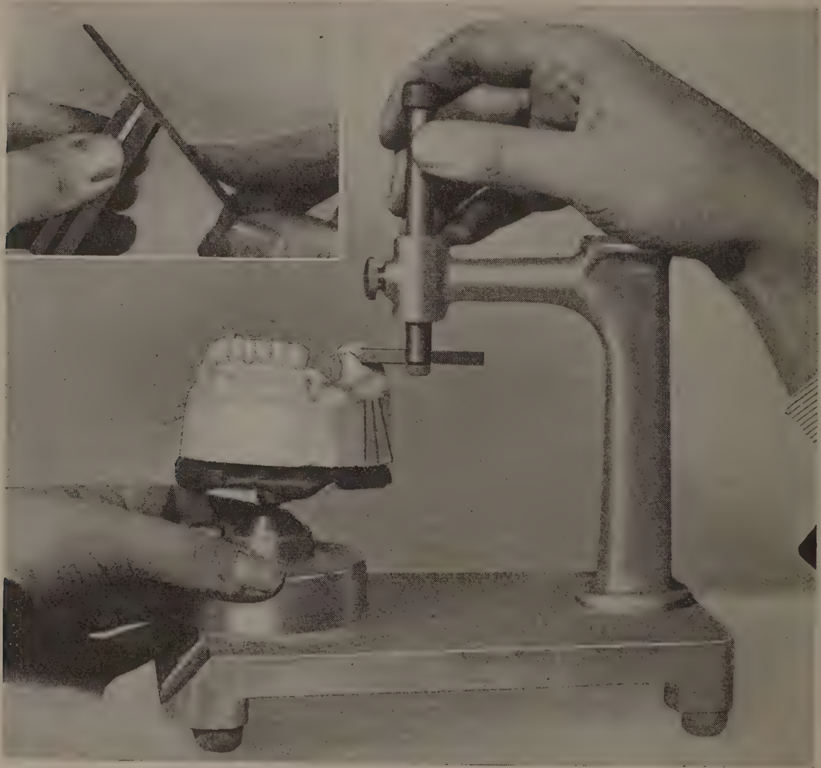

FIG. 267.—Tracing the guide line, using the Ney surveyor. This is done after the path of insertion has been determined and the table tilted so that it corresponds with the vertical marking member. Inset shows the process of squaring the graphite marker, which is thereby made parallel with the vertical marking member.

The Position of the Guide Line on a Tooth Depends on the Path of Insertion.—The position of the guide line on a given tooth varies with the path of insertion. In other words, the guide line on a tooth with a path of insertion parallel with the long axis of the crown would differ from the guide line for a path of insertion oblique to this long axis. This is apparent in surveying. Conversely, should the guide line appear in an unfavorable position, in some cases the path of insertion may be changed to cause a more favorable position of the guide line.

Steps in Designing Wrought Clasps.—*Presupposing denture design to be tentatively completed:* 1. Make individual impressions of teeth to

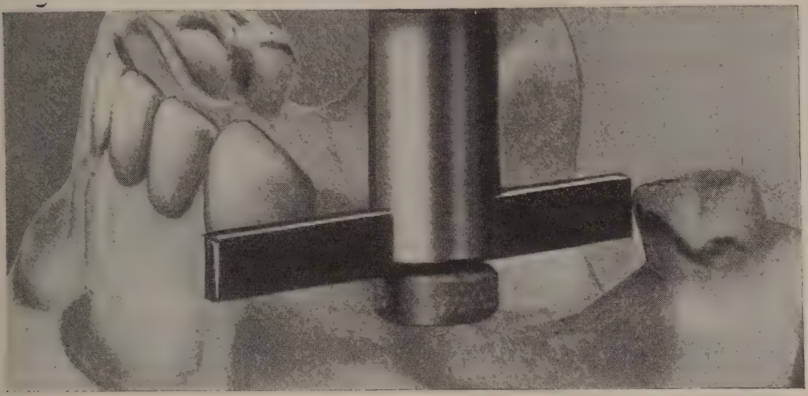

FIG. 268.—Enlarged view of the graphite marker outlining the guide line, as seen in Fig. 267.

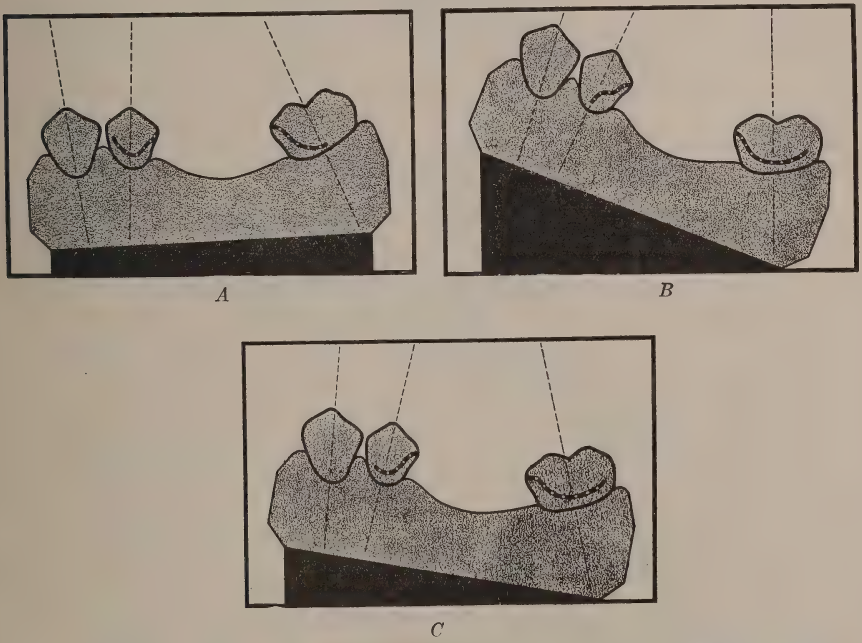

FIG. 269.—The interdependence of the guide line and the path of insertion. In *A* the path of insertion too closely approximates the long axis of the bicuspid, giving a favorable guide line to it, but not to the molar. In *B* the condition is reversed, while in *C*, the average between the long axis is chosen with favorable guide lines for both. It may readily be seen that, with experience, the path of insertion may be changed to secure more favorable guide lines.

be clasped with fusible metal models for wrought clasps, and cast-clasp investment models for cast-clasps.

2. Take modeling compound impression of occlusal surfaces of teeth only, set these models therein and mount in temporary plaster base with at least ¾-inch base. This is a temporary surveying cast.

3. Mount on surveyor table, using modeling compound.

4. Determine mean direction of axes of two or three teeth used for clasps, or, if mucosa supported, the direction in which the denture will be depressed into the mucosa during function; modified if necessary as in Fig. 269. *This is the path of insertion chosen.*

5. Make guide lines with surveyor, on teeth to be clasped.

NOTE.—Should the dentist prefer to outline these clasps freehand, steps 2, 3, 4, 5 may be omitted.

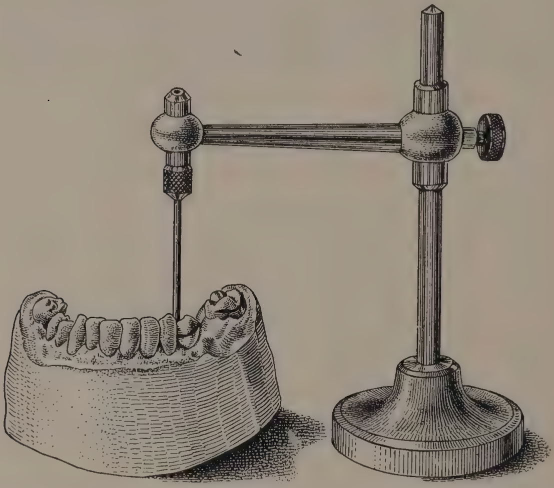

FIG. 270.—A simple type of surveyor, the Robinson surveyor, the result of the studies of the Philadelphia Dental Clinic Club.

6. Choose position of arms of clasps on the guide line.

7. Choose position of body of clasp also on guide line, keeping it occlusally to guide line. Choose type of arm and outline the entire clasp.

NOTE.—The distance which the arms of the clasp should be placed gingivally to the guide line should not ordinarily exceed 2 mm. The greater the amount of convexity, the closer may the gingival clasp line of the arm of the clasp approach the guide line. Also, the more resilient the metal in the clasp, the further away the arm may be gingivally from the guide line. (See Fig. 273.)

NOTE.—Many operators prefer to take a single main impression, pouring the cast either with integral or separable retaining teeth (teeth to be clasped) rather than *the method above described, in which* *the clasps are completed and in the mouth during the taking of the main impression.*

For this single-impression method absolute accuracy of every detail about the retaining teeth is essential. A method is proposed on page 382.

Individual Impression and Casts of Low-fusing Metal for Clasps.—The individual impression is essential in cases in which it is difficult to determine in the mouth the location of opposed convex surfaces. It must be taken in plaster, and may be readily divided into two sections with a Gritman plaster dividing knife, or similar knife, and having been reunited in the tray, surrounded by a strip of Plasticine, about $\frac{1}{8}$ inch thick and filled with low-fusing metal (Fig. 272).

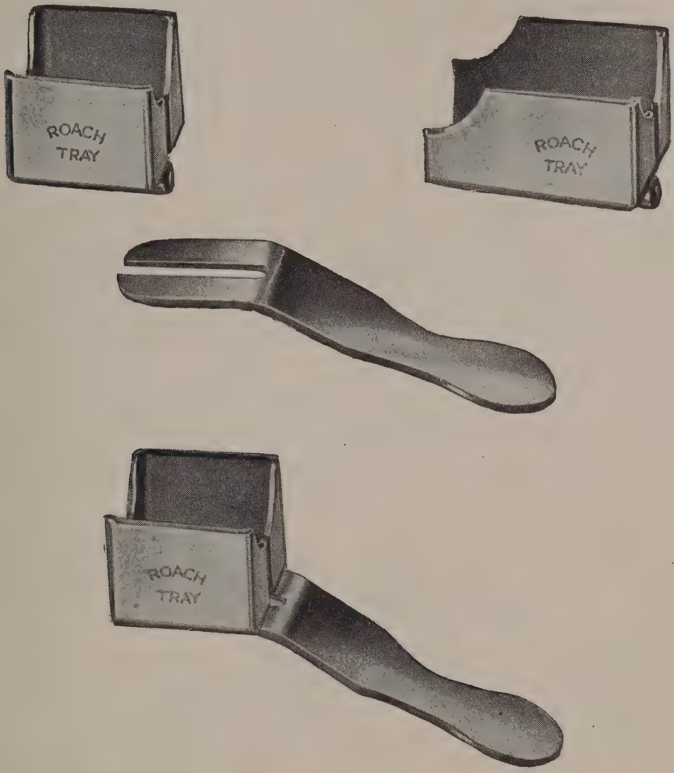

Fig. 271.—The Roach tray for impressions of individual teeth, or small groups of teeth.

To obtain the best result, it is desirable to introduce the low-fusing metal into the impression immediately after removal from the mouth. A little care in the pouring of the low-fusing metal will prevent bubbling and consequent pitting of the low-fusing cast as follows:

A copper ladle, preferably thin, is filled with metal ingots, or previously made and discarded casts, and held over the flame, carrying it rapidly in and out of the flame. When three-fourths of the metal is melted, remove the ladle from the flame and allow the excess heat in the melted portion to melt the remaining unmelted portion, thus insuring the minimum temperature at which the metal is plastic. It is also well to "jar" the mold held in the left hand and rap it on the bench, while the metal is poured in, using the right hand.

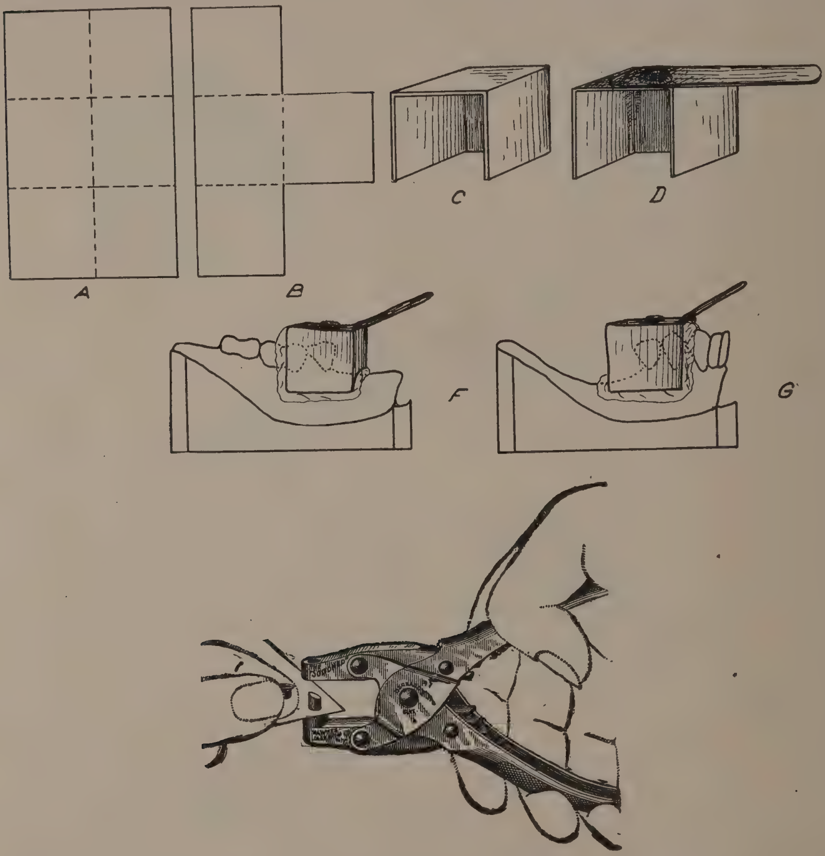

Fig. 272.—Trays suitable for impressions of individual teeth may be made as follows: *A*, sheet of "air-chamber metal," so-called, rolled to 20-gauge and cut to from 2 to 6 cm., to 2.5 x 7.5 cm., depending on small or large teeth; *B*, cut out square, leaving limbs either 2 x 2 cm. up to 2.5 x 2.5 cm., depending on size of tooth; *C*, bend as shown for open side box; *D*, movable handle rivetted on with "solidhedeyelet" punch, sold at commercial stationers; *E*, "Solidhedeyelet" punch and eyelet; *F* and *G*, tray in position on mesial and distal surfaces of teeth.

Choice of Opposing Convex Surfaces.—These may be chosen upon any opposing areas located upon sound enamel, and well distant from the gingival margin (Fig. 273). On teeth standing isolated from their fellows with sufficient spaces to admit of a clasp, different sets of opposing convex surfaces are frequently found. For example, in an upper cuspid spaced from the upper lateral incisor, the sets of opposing convex surfaces are two in number, *i. e.*, *A* the contacts and *B* the labial or lingual surfaces.

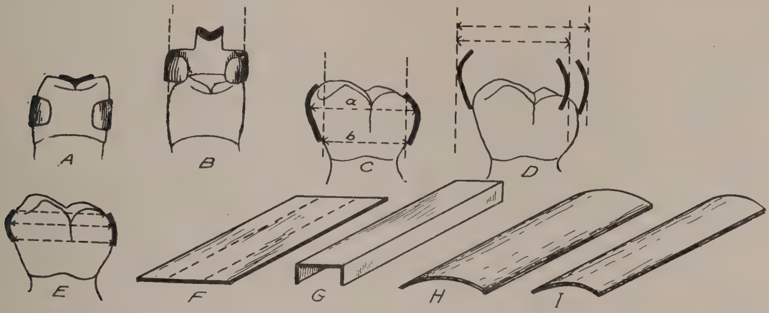

FIG. 273.—Some considerations in the use of a wide clasp (either wire or band) or of a single wire clasp too close to the gingival aspect on a tooth of small opposing convexity, and for a tooth of greater convexity. *A*, wide clasp in position on a tooth of small convexity (the separation of the free ends in removal or insertion is comparatively little, hence small strain on the anchor tooth itself; *B*, showing the separation of the arms in *A;* *C*, wide clasp in position on a tooth of decided convexity; *D*, note the great separation of the arms for removal and insertion and consequent strain on anchor tooth; *E*, narrow clasp on convex tooth (note lesser amount of separation of free ends and consequent lesser strain on anchor tooth). Note.—*If the lower border of the clasps in C, D and E were taken as the position of single wire clasps, it will be seen that considerable pressure would be needed to insert and remove at C and D, and much less at E. The use of the surveyor eliminates all guesswork in this particular.* *F*, *G*, *H* and *I*, a study in sheet metal forms and resiliency; *F* represents a sheet of clasp metal, great resiliency; *G*, same piece in channel form lacks resiliency altogether; *H*, concave form very much stiffer and less resilient than *F*, while *I*, being narrower, more closely approaches *F*. Inference: From the cross-section, these clasps lose resiliency as they acquire contour, therefore care in proper width for convex teeth is necessary.

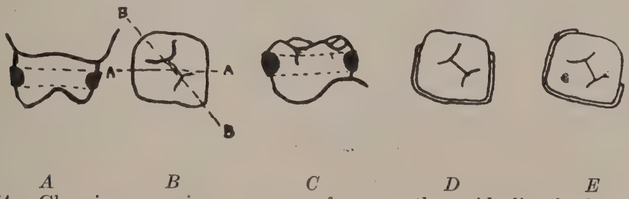

FIG. 274.—Choosing opposing convex surfaces on the guide line for bucco-lingual, mesio-distal or line-angle clasp. *A*, convex surfaces, bucco-lingual, but unsuitable because the clasp would be thrown off rather than retained; *B*, *A–A*, the bucco-lingual, and *B–B*, the line-angle pair of suitable opposing convex surfaces; *C*, arms of line-angle clasp fitted to the opposing convex surfaces; *D* and *E*, plan of bucco-lingual and line-angle clasps.

Distance of Wire (or Width of Clasp) from Opposing Convex Surfaces.—As a general rule the width of the clasp at the line of opposing curved surfaces of a tooth should vary proportionally with the lack of curvature at that line; in other words, wide clasps are indicated for opposing convex surfaces which more closely approach the parallel, and narrower for those which show marked convexity, by reason of the harsh reaction during insertion or withdrawal upon a tooth of marked convexity of a wide clasp lacking in resiliency (Fig. 274). *If the cast is surveyed, the guide line will pass in the middle of these opposing convex surfaces.*

Construction of Wrought Clasps.—For the following original and most valuable technic for swaging wrought clasps, the writer is indebted to Mr. George L. Roth of the Technicial Department of J. M. Ney & Co.[1]

Certain materials and appliances are necessary. These are as follows: Fusible metal, pattern wire, ½ round 14-gauge, round 17, 18, 19, air-chamber metal 24-gauge, clasp metal and bending pliers and rubber tubing as follows:

1½ inches x ½ inch inside measurement.
⅝ inch " "
1 inch " "
1½ inches " "

By reason of the number of illustrations[2] of this technic, only the steps in the technic are given. The double wire clasp is also shown in Fig. 286.

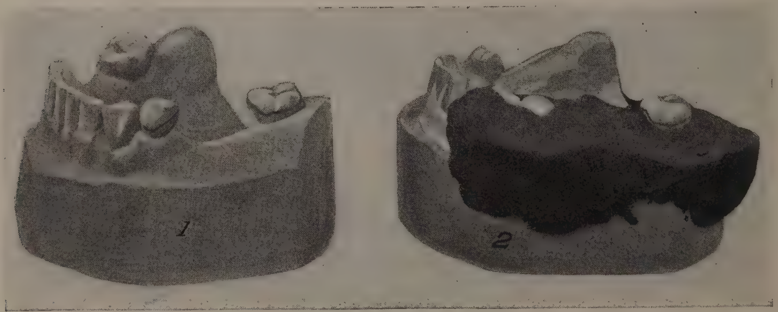

Fig. 275.—The round wire clasp, Roth technic: *1*, guide line is indicated by pencil mark; *2*, plasticine trimmed for 17-gauge wire. For smaller than 17-gauge, trim slightly less; for larger, trim slightly more.

Wrought Single Wire Clasp.—Roth technic (Figs. 275 to 280).

(*a*) Bank with plasticine, and trim below the guide line to allow for the thickness of the wire used (18- or 19-gauge) (Fig. 275, 1, 2).

(*b*) Oil and take plaster impression, trim the impression parallel to the occlusal plane of tooth, cut in two parts and carefully remove and reassemble (Fig. 276, 3, 4, 5).

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[1] This technic has been prepared for use in conjunction with a surveying instrument. Should, for any reason, the surveyor be not used, the guide and clasp lines may be drawn freehand. Frequent annealing is necessary. The results obtained will increase in accuracy in proportion to the amount of hand-bending before swaging between dies.

[2] These illustrations are taken from the Ney Technician, No. 1: Swaging Wire Clasps, by George L. Roth; it is through the courtesy of the J. M. Ney Company, Hartford, Conn., that they appear here.

(*c*) Set in moldine (preferred to plasticine for contact with fusible metal) on a flat table top or similar surface. When there is an adjoining tooth, build up the impression approximately to the contact point (if necessary) (Fig. 277, 6).

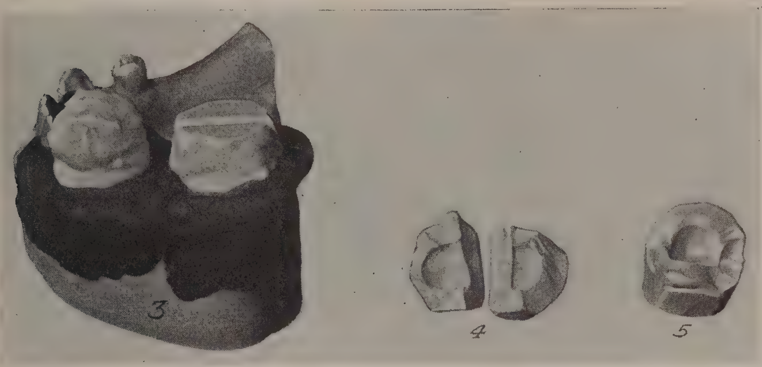


FIG. 276.—*3*, molar impression trimmed flat on top before making incision, which should be mesio-distally; *4*, *5*, plaster impressions.

(*d*) Select a rubber tube 1 inch inside diameter, 1½ inches long, press on moldine, pressing it up the sides to prevent escape of the metal (Fig. 277, 7).

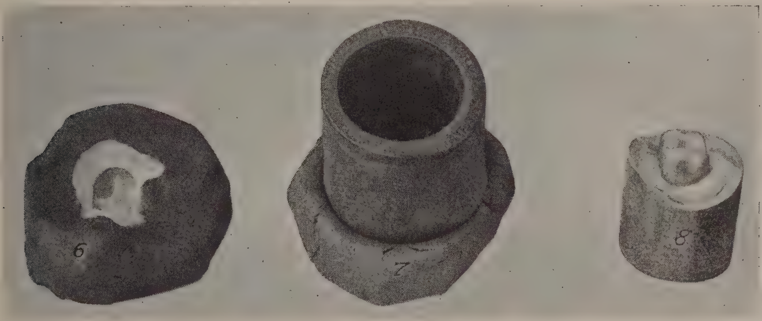


FIG. 277.—*6*, impression surrounded by moldine (if it has dried after setting, moisten the impression by momentary immersion in water); *7*, rubber ring in position (if it pulls the moldine away from the plaster, smooth toward the impression with curved end of spatula); *8*, die cast and separated.

(*e*) Pour the die in fusible metal. Using the copper ladle, hold the metal over the flame until thoroughly fluid, allow it to thicken, stir and pour while fairly thick, filling the rubber tube (Fig. 277, 8).

NOTE.—Dies and counterdies should in all cases be at least 1½ inches in length.

(*f*) Select pattern wire, 18-gauge or smaller.

(*g*) Twist, with twisted end coming between arms of clasp, press to position with spatula or burnisher. (Roach double-ended wax carver recommended.) Twist tight, press well into place with this instrument, and cut twisted end off. Scratch the die above pattern wire and remove pattern wire. Scrape off contours of die down to line so that the die will be conical in shape, leaving gingival seat intact, permitting draft of counter-die (Fig. 278, 11, 12).

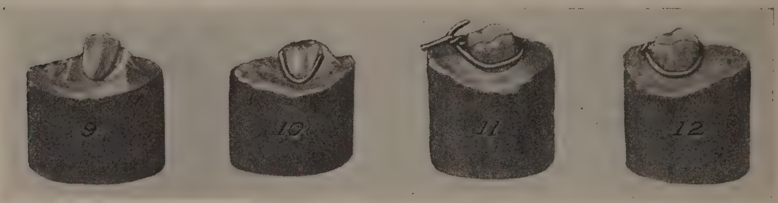


Fig. 278.—*9*, cuspid, with adjacent lateral impression filled with moldine; *10*, pattern metal wire burnished in place, ends tucked into interdental spaces, when adjacent tooth prevents use of twisted loop; *11, 12*, loop with twist located opposite to proposed body of clasp, *i. e.*, point of connection with denture.

(*h*) Apply moldine over twisted ends, paint the die with whiting and wood alcohol and ignite. A uniform coating of dry whiting will result (Fig. 279, 13).

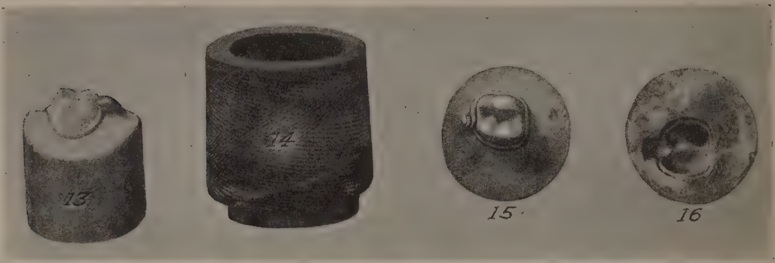


Fig. 279.—*13*, die ready for counter-die (undercut formed by bell of tooth above pattern wire, removed before application of whiting and alcohol); *14*, rubber ring in position upon die; *15*, die separated from counter-die, pattern wire in position; *16*, counter-die (edge of groove where dialoy has flowed under pattern wire removed with point of knife, if necessary).

(*i*) Apply rubber ring to the die and pour the counter-die. To be safe have the base of the die in cold water (Fig. 279, 14, 15, 16).

(*j*) Using pattern wire for proper length, make a soldered ring (suggestion of Dr. W. G. Switzer) of elastic round wire (18-gauge). Have soldered joint between the ends of the arms during swaging, to be later removed. Adapt this to the die with pliers, also triangular piece 24 plate 36-gauge, to be placed in the body of clasp. Burnish latter with 2 mm. projecting past the clasp. Swage both between dies, using a 3-pound hammer, two or three strokes (Fig. 280, 17).

(*k*) Burnish projecting part back over the wire and reswage.

(*l*) Remove from die, paint lower surface of 24-K. matrix with anti-flux, reinforce well with casting gold or similar, if clasp is to support denture; if not, use 20-K. solder, to be later removed. (Casting gold is considerably stronger than solder; fusion 50 or 75 degrees below other metal is safe.) (Fig. 280, 18, 19, 20.)

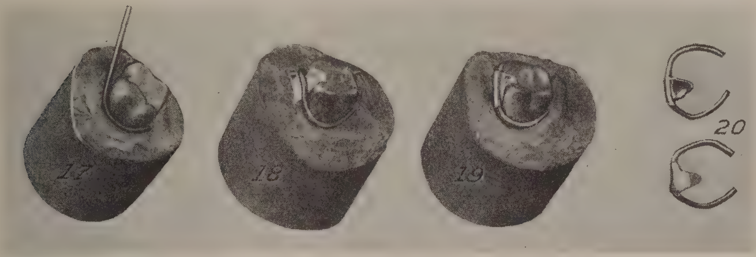


Fig. 280.—*17*, clasp wire partly adapted, using Peeso No. 2 or Robinson collar pliers, edges rounded to avoid nicking wire; *18*, wire swaged with matrix (perfect adaptation of wire before swaging unnecessary, but must fit at center and ends); *19*, end of matrix lapped over wire, burnished and swaged; *20*, matrix ready for soldering and matrix reinforced.

The Half-round Wire Clasp (Roth Technic).—This is constructed in a similar manner to the round-wire clasp except that 14-gauge half-round pattern wire is used. After the pattern is formed, lay it flat on the bench and first adapt elastic half-round wire against the wide cross-section to correspond to the pattern. Bend approximately against the narrow cross-section on the model and swage.

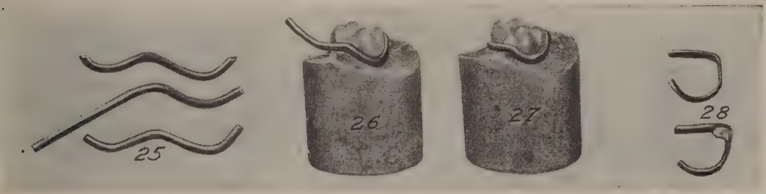


Fig. 281.—The half-round wire clasp, Roth technic: *25*, half-round pattern wire flattened; half-round clasp wire partly bent edgewise, wholly bent edgewise to coincide with contour curves in pattern wire; *26*, *27*, *28*, clasp wire partly adapted to the die; clasp wire swaged; clasp wire before and after addition of occlusal rest.

The Wrought Single Crib.—This is the Jackson crib, invented by Dr. V. H. Jackson as a retainer for removable orthodontic appliances. Its special application is in cases in which retention is desired upon a tooth which lies *in the center of a series of remaining natural teeth lying closely in contact.* Examples will be found in Squares 17, 18, 21 and 24, in Plate I). In all cases there must be space for the 20-gauge wires crossing the contacts of the remaining teeth.

The stages in the construction of the wrought crib here follow:

(*a*) Bank with plasticine, trim below guide line the thickness of the wire used (19- or 20-gauge) (Fig. 283, 29).

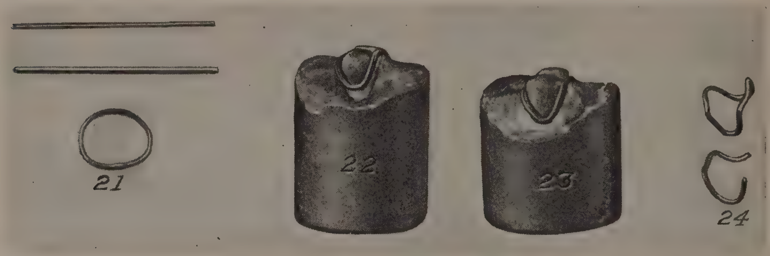


Fig. 282.—The Jackson crib for bicuspid, Roth technic: *21*, pattern wire measurement, clasp wire same length, and latter formed into ring and soldered; *22*, *23*, *24*, ring approximately adapted to the die; ring swaged to position; ring before and after conversion into a clasp with the soldered joint cut out.

(*b*) Oil and take plaster impression, trim impression parallel to occlusal plane of tooth, cut in two parts and carefully remove (similar to that in Fig. 276).

(*c*) Pour metal die, as before, reassemble impression, varnish it; then pour investment compound model for soldering (if a lingual friction plate is desired) in the same impression.

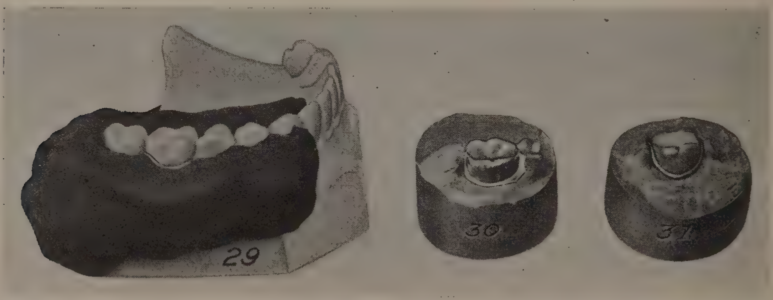


Fig. 283.—*29*, working cast with position charted for crib, and plasticine trimmed for plaster impression; *30*, *31*, lingual plate swaged; wire ring swaged with soldered joint at lingual surface.

(*d*) Apply pattern wire, 20-gauge to metal tooth the same shape as crib, twist on the lingual surface. Scratch, remove, scrape labial side only to line for draft.

(*e*) Return pattern wire to the die, press into place, apply a little moldine over the twist, apply whiting and rubber ring, pour counter-die and separate, as in Fig. 279.

(*f*) Remove pattern wire, cut, straighten out and cut 19-gauge (molars) or 20-gauge (bicuspids) the same length as the pattern. Bend this into a ring and solder with a piece of casting gold (C or G) or similar. Then bend this approximately to the shape of the crib (Fig. 282, 21).

(*g*) Cut, burnish, trim and swage a piece of 24-K. 36-gauge plate for the lingual side, if lingual tenso-friction is desired. Lay to one side (Fig. 283, 30).

(*h*) Swage the crib between dies and remove. If lingual plate is not desired, the crib is now finished (Fig. 282, 24). If lingual plate is desired, cut a section of wire at the lingual and gingival aspects, place pure gold-piece already swaged on investment compound model; slightly open (if necessary) and slip crib over, with cut-open section over pure gold on the lingual. Solder and build out with clasp metal (C or G) or similar (Fig. 283, 31, 284, 32 and 33).

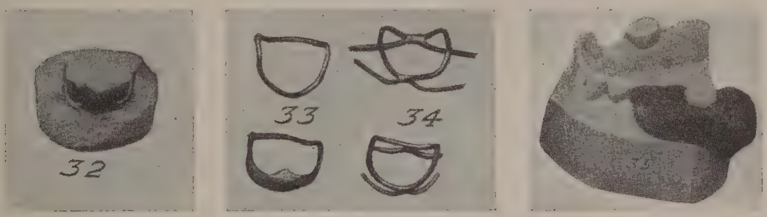


Fig. 284.—A molar crib and modifications, as described in the text. *32*, matrix for lingual plate, and crib with lingual segment cut-out, invested for soldering and reinforcement; *33*, crib without, and crib with, reinforced lingual plate (crib contraindicated when bite is too close for wire on occlusal surface); *34*, Crozat attachment (frequently employed upon short teeth where bucco-lingual grip must be augmented by mesiodistal grip); *35*, plasticine trimmed for first impression for main structure of wire clasp.

The Wrought Multiple Crib (Roth Method).—For cases with a series of remaining natural teeth on one side only, the wrought multiple crib is desirable.

Examples may be found in Plate III, Squares 49, 54. The stages in the construction are as follows:

(*a*) Bank with plasticine and trim below the guide line, to allow for the thickness of the wire used (20-gauge).

(*b*) Oil, and take plaster impression, trim impression parallel to occlusal plane of the tooth, cut in two parts, and carefully remove.

(*c*) Pour metal die, as before, using 1½ x 1½-inch rubber tube; reassemble the impression, varnish it and pour soldering investment compound model.

(*d*) Make crib on the middle tooth of pattern wire; remove it.

(*e*) Make crib on end teeth of pattern wire, cut and slip ends of pattern wire under postion of middle crib in embrasure. Replace middle crib, making triple crib of pattern wire.

(*f*) Add moldine to twist on middle crib, paint with whiting and alcohol, burn off, slip on 1½ x 1½-inch rubber tube and pour counter-die as before.

(*g*) Cut wire and swage center crib as before.

(*h*) Cut and bend ends of cribs under middle crib; swage all three together.

(*i*) Assemble, solder on investment model.

(*j*) Cut out segments of end cribs, converting these to clasps, if desired, and reswage.

NOTE.—Lingual friction plate or plates may be used here also if desired. The construction is the same as for the single crib.

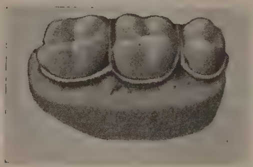


FIG. 285.—Finished wrought multiple crib, with the centers cut from the end cribs, converting them to bucco-lingual clasps. The above shows the final stage in the construction.

The Wrought Band Clasp (Roth Technic).—The advances made in the methods of construction of the round and half-round clasp have almost displaced the wrought band clasp which has been standard for so many decades. The writer is unable to concede that this clasp must be discarded suddenly, and for all time. Two reasons here follow, namely: The greater resiliency of the arms of a wrought band clasp over those of the lightest of the wire clasps, due to a difference in the gauge of the metal used; a 19-gauge (B. & S.) round wire (0.036 inch) as against a 24-gauge flat clasp metal plate (0.020 inch), in which the plate is a little over one-half the thickness of the wire with, other conditions being constant, if anything, a greater life under function. Second, when flexible connectors are used, there is a positive indication for three-arm clasps having arms extending both occlusally and gingivally from the guide line, and thus grasping with utmost firmness the natural tooth to which it is attached. This narrows down the

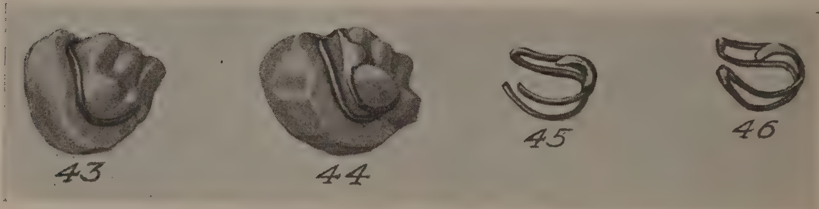


FIG. 286.—The loop clasp, Roth method. As may be seen, this is two single-wire clasps swaged above or below the guide line and subsequently united with casting metal. *43*, lower wire in position on investment model; *44*, both wires in position; *45*, wires joined at one clasp extremity; *46*, wires joined at both clasp extremities.

choice of clasps to the loop clasp (Fig. 286) and the band clasp, the latter having more resiliency in the arms.

As for many decades past, in locations where flexible connectors (stress breakers) are indicated, and in mouths comparatively immune to caries, and upon good enamel, it is probable that the band clasp will find a place, if a much more restricted place, in the scheme of Standard Parts in Partial Denture Service.

In the Roth method, a small die is made, with the shoulder corresponding to the gingival clasp outline. The pattern is then made of 24-gauge lead, and the die is made to sandwich between two other dies.

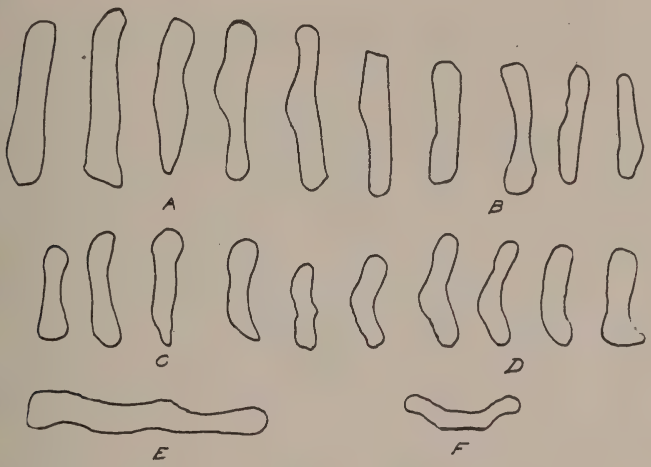


Fig. 287.—The wrought clasp is proposed by the writer in the text as still having a place (much more restricted) in dentistry. Here are shown a variety of clasp patterns, as occurring in routine practice in the Canadian Army Dental Corps. *A*, molar clasps; *B*, bicuspid clasps; *C*, cuspid, labio-lingual clasps; *D*, cuspid, mesio-distal clasps; *E*, multiple clasp for two upper molars; *F*, cuspid, clasp.

The stages of construction here follow:

(*a*) Sketch gingival and occlusal clasp lines, bank with plasticine, and trim exactly to gingival clasp line.

(*b*) Oil and take impression, trim impression parallel to the occlusal plane of the tooth, cut in two parts, and carefully remove.

(*c*) Trim impression until the sides are 1 mm. wide.

(*d*) Slip ½ x 1½-inch rubber tube over impression, pour in fusible metal, resulting in die 1 inch long, and with narrow shoulder.

(*e*) Take ½ inch garnet disk and trim, if necessary, the shoulder to a bevel so as to see the gingival margin.

(*f*) Burnish clasp pattern, 24- to 26-gauge sheet lead, or air-chamber metal.

(*g*) Embed die half way in moldine with one arm of clasp pattern down; if necessary, cover cusps with moldine for draft of counter-die; add whiting and wood alcohol, burn off alcohol.

(*h*) Press rubber tubing, $1\frac{1}{2}$ inches inside diameter by $1\frac{1}{2}$ inches long, on moldine, and pour upper die as before. Cool well.

(*i*) Remove metal tooth clasp pattern and die just poured from moldine, add a little moldine on occlusal surface of metal tooth if necessary for draft, readjust lead clasp pattern if necessary, apply whiting and alcohol to metal tooth and its die in position, burn off, slip same tube over die, and pour counter-die. We now have two counter-dies with the metal tooth and its lead pattern sandwiched between.

(*j*) Take lead pattern, cut clasp plate, bend it approximately to the metal tooth. Place between die and counter-die and swage with two or three strokes of a 3-pound hammer.

Adaptation of Metal, Previously Cut to Shape from Pattern.—Frequent annealing is allowable because in the assembly a certain amount of annealing is unavoidable, hence no disadvantage occurs if this be done. The contouring process should begin at one of the arms which should be contoured until finished. Then the line-angle of the tooth must be turned and care must be taken to bend the clasp at this point to harmonize with the line-angle, otherwise an inaccuracy will develop. (See Fig. 288.)

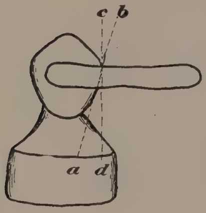


FIG. 288. — Showing correct and incorrect manner of bending the clasp around the line-angle on the fusible metal cast, the arm in contact with the cast having been contoured. *a–b*, correct bend, corresponding with the line-angle of the tooth; *c–d*, incorrect bend, not corresponding with the line-angle of the tooth.

Not infrequently the necessary use of the hammer and pliers in bringing the metal in place will beat down the high contours on the fusible metal cast. In this event, a second, or even a third, impression and cast will be necessary. It is also always advisable to try clasp in the mouth to check this up before work on the occlusal rest is begun.

Multiple Wrought Clasps.—In certain unilateral restorations (those in which all available anchor teeth are located on one side of the mouth) the multiple clasp, or clasp which engages more than one tooth, will be of immense advantage. An instance of this is shown in Plate III, Square 45, the only two remaining natural teeth in the lower jaw. *It must be borne in mind that these cases are rare, and that full dentures are usually indicated.*

The construction of the multiple band clasp formed of sheet clasp metal is identical in many respects with that for the single tooth. An individual plaster impression is made of both teeth (which must be in actual contact) and the opposing convex surfaces chosen on them (Fig. 289).

Clasps Lined with Pure Gold for Tenso-friction.—Occasionally, for the parallel-sided tooth in which little or no facility exists for the use of contoured arms of clasps, a friction lining is used, as in Fig. 292. Pure gold is ordinarily used for this purpose, which exerts considerable friction on the enamel.

The procedure is as follows: The clasp is made in the usual manner and removed, and pure gold burnished on the fusible metal cast a little wider than the clasp. The clasp is then returned to place over the pure gold, the two waxed together, invested and joined with solder. Should it be expedient, a surface occlusal rest may be developed by carrying the pure gold on to the occlusal surface.

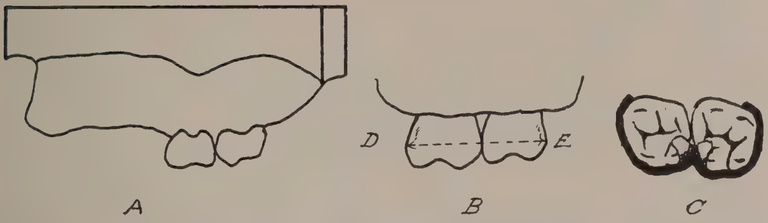


FIG. 289.—Multiple clasps for two or more teeth in contact: *A*, lateral view; *B*, showing opposing convex surfaces against which the arms of the clasps are fitted (*D–E*).

Modifications of Band Clasps.—Occasionally a tooth is selected for a direct retainer which is entirely suitable for a clasp save for one reason, namely, a faulty enamel surface, such as would, in the mind of the operator, be possibly affected by capillary attraction of saliva and food. The faulty enamel, or occasionally a contact predisposed to caries, should not be covered by the clasp. By carrying the 14-gauge wire connector across the occlusal surface, the clasp may be relieved at this point, as shown in Fig. 290.

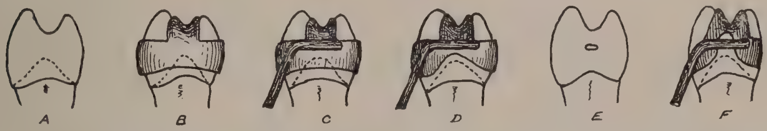


FIG. 290.—The relief of clasps for faulty enamel: *A*, tooth with predisposition to caries, usually from a previous case on adjacent tooth; *B*, band clasp with surface occlusal rest fitted over, not relieved; *C*, 14-gauge wire carried to occlusal end of line-angle, then across the clasp; *D*, relief then made by removing clasp metal over predisposed portion (the wire compensates for the loss of metal); *E*, predisposition at the contact point of tooth to be clasped; *F*, relief for this condition, wire carried across and metal removed immediately over the contact point (into which a filling has been placed).

Also, in occasional instances, if the labial free end of a clasp occupies a conspicuous position, this may be reduced by forming a recess or window in the clasp by stone and fissure bur. Usually, in order to offset this reduction of metal and consequent resiliency, it becomes necessary to flow casting gold over the remaining portion of the clasp (Fig. 291).

Cast Clasps.—Cast clasps are particularly useful in affording retention at the end of enclosed spaces (with a natural tooth at each end). In root-supported restorations; or in combination-supported restorations with a minimum of rotation under function; or a combination-supported denture attached to it by a flexible connector. They may be used with safety under other conditions with flexible connector. Cast clasps should be polished inside as well as outside to remove the silicious remains of the investment; and should be free from minute recesses in the metal.

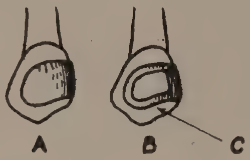


Fig. 291.—Reducing the conspicuity of a clasp by cutting window, subsequently reinforced with casting metal: *A*, clasp which occupies a conspicuous position; *B*, window formed in the above clasp which is subsequently reinforced at *C*. *This is an alternative method of the loop clasp*, Fig. 286.

Under present conditions, partial dentures whose designs include cast clasps are often constructed as integral with a casting which includes the entire framework. Hence a further reference will occur under the head of construction (see p. 379).

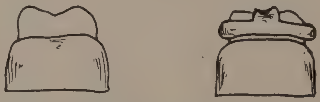
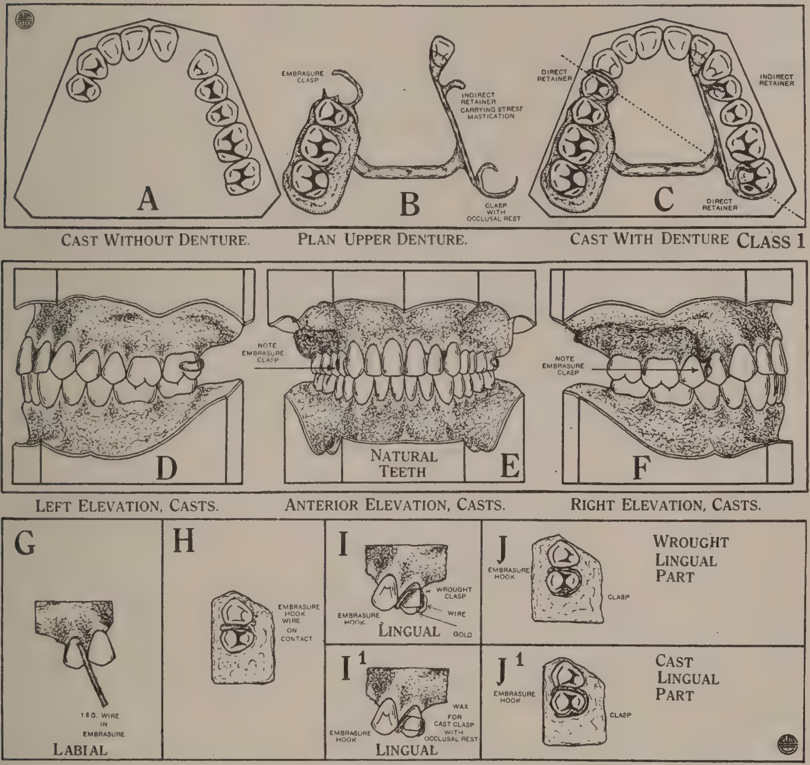


Fig. 292.—An indication for a cast clasp. A short tooth with little convexity, good enamel and used under conditions described in the text.

The Roach Embrasure Clasp.—This is a most useful clasp, designed by Dr. F. E. Roach of Chicago, and particularly well suited both for bicuspids and cuspids in which the bucco-lingual clasp might be thought conspicuous. It is usually made up of two arms and a body, but with the elastic wire arm passing over the contact point, and into the labial embrasure. In its usual form it is in a sense, partly mesio-distal and partly bucco-lingual as noted. The great advantage of this clasp lies in its inconspicuousness. Double forms of this clasp, usually with cast or built-up bodies, and with wrought elastic wire arms passing over the contact points and terminating in the embrasures, are extremely useful in making an attachment in the center of a series of teeth, similar to the method of using the Jackson crib.

The Three-arm Clasp.—These are practically the two-arm clasps with occlusal rests attached to the bodies of these clasps where such rests are desirable. The various types of occlusal rests, with or without clasps, are considered elsewhere.

The One-arm Clasp.—Reference to Fig. 294 will show the one-arm clasp as the type of clasp having but one arm and no body. For this reason it requires at least two other direct retainers, disposed in a triangular relation to it. The one-arm clasp, resting on a sloping convex surface, then reciprocates with the convex surfaces to which the other two clasps are applied on the remaining natural teeth, thus affording retention.

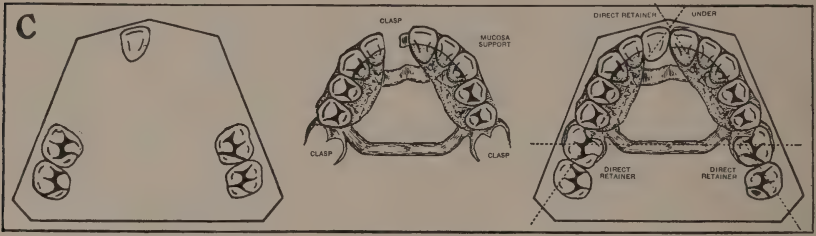

CAST WITHOUT DENTURE. PLAN UPPER DENTURE. CAST WITH DENTURE CLASS 1

LEFT ELEVATION, CASTS. ANTERIOR ELEVATION, CASTS. RIGHT ELEVATION, CASTS.

FIG. 293.—The embrasure clasp and steps in its construction. *A*, *B*, *C*, plan of a restoration, using the embrasure clasp; *D*, *E*, *F*, elevation of same restoration on casts, showing appearance labially of embrasure clasp; *G*, applying the 18-gauge elastic wire to labial embrasure of cast; *H*, having applied the 18-gauge wire to the embrasure, the wire is then bent over the contact point as shown (should occlusion interfere it may be necessary to polish a little off both the interfering cusp and the marginal ridges of the teeth to which the clasp is fitted); *I*, pure gold then burnished on distal and lingual side and slightly on buccal side, sufficient to form an opposing arm grasping the opposing convexity opposite the embrasure hook (this is carried also occlusally and reinforced by an extra piece of 18-gauge wire if an occlusal rest is desired). *J*, solder (using casting gold) applied, clasp polished and main impression taken; or, I^1, J^1, wax is here applied and casting made and subsequently soldered.

The one-arm clasp is the only safe clasp which may be applied with a rigid connector to central or lateral incisors, upper or lower.

Clasps to be Completed Before the Main Impression.[1]—If ordinary methods of impression-taking are used, it is recommended that all clasps with or without occlusal rests, band or wire loop, should be completed and fitted to place in the mouth before impressions are made, because of the necessity for accuracy in the relationship of the clasp to the other tissues in the forthcoming cast.



CAST WITHOUT DENTURE. UPPER DENTURE. CAST WITH DENTURE CLASS 4

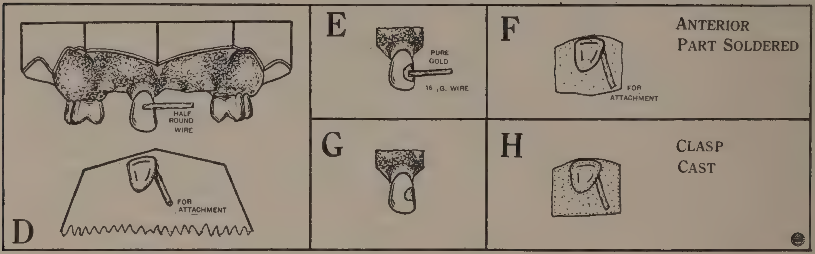


FIG. 294.—The one-arm clasp, its use and construction: *C*, one-arm clasp, opposed by artificial tooth with strong lower occlusion (this design would be better with larger saddle); *D*, the simplest one-arm clasp; half-round clasp wire bent as shown in the illustration; should the wire in the upper figure be required to turn more or less abruptly toward the mucosa, grasp in pliers and bend against the wider cross-section; *E*, one-arm clasp made with pure gold, burnished against metal model with 16-gauge wire fitted as shown; *F* shows position of wire ready for attachment; this is invested and soldered with the highest karat solder possible; *G*, *H*, stages in waxing for all-cast half-clasp; Solbrig thin wax for labial portion, 16-gauge wax wire for the balance; casting is made in elastic gold.

Note.—At *C* is illustrated a principle in design to provide for the loss of retaining teeth. Should at any time the central incisor be lost, an indirect retainer carried back to the molars (similar to the design shown in Plate II, Square 27), along with a new artificial central incisor, will restore the denture to its former usefulness.

Other Methods of Simple Direct Retention.—A number of other simple direct retainers are already well described in the literature, to which the writer will, due to lack of space, omit reference. The various clasps of Drs. Gillett, Roach, Goslee, Beach, Rice and others can be studied to the greatest advantage.

Adhesion.—While the force of adhesion, of prime importance in edentulous cases, is of secondary importance in partial dentures, yet, in certain cases in which its use would relieve the few remaining teeth of undue strain (Plate III, Squares 47 to 49) its importance is considerable. In such a case the original Greene method of securing impressions or as modified by Supplee and others, using Kerr's compound, with trays avoiding the muscle contraction, and, if necessary, the sectional method, allowing the impression of all but the labial surfaces of the teeth to be returned to the mouth, with softened edges for muscle trimming until the impression passes a test for adhesion by remaining in position while the patient makes dislodging movements, and, with the first impression in position, the subsequent adjusting of a separate piece of compound representing the labial surface, will secure a high degree of adhesion.

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[1] If the impression methods used result in casts of exceptional accuracy, as, for example, the method described on page 382, the impression may be made first, and the clasps subsequently surveyed and made upon such a cast.

Adhesion depends on molecular attraction between a film of saliva held in position by capillary attraction and the base on one side and the mucous membrane on the other.

Capillary attraction is lessened as the approximating surfaces become separated, therefore it is especially necessary in securing good adhesion to preserve close contact at the periphery, avoiding, however, the detaching influence of muscular contraction. It is patent also that the amount of adhesion is in direct proportion, not only to the accuracy of the adaptation, but to the area of adaptation. Therefore, the diminishing importance of adhesion in small saddles. The above-mentioned technic seems a method of securing adhesion in harmony with physical laws.

Compound Direct Non-precision Retainers and Their Indications and Contraindications.—All compound direct retainers are made up, as already stated, of two interlocking elements, one of which is attached to the denture and the other attached to the tooth by means of inlay, crown, bridge or similar device.

The indications for the use of compound retainers is clear cut, namely, upon: (1) The teeth desirable for retention, having carious cavities, faulty enamel or any condition requiring inlay or other reparative work; (2) fillings, inlays, crowns or even bridges fixed, which may be removed and replaced with one of the members of the compound retainer attached by solder; or, in a word, teeth with crowns whose contours must be wholly or partly restored, or which are entirely unsuitable for clasp retention. The practice of cutting into sound teeth, which are suitable for clasp retention, for the sake of using compound retainers (a thing quite occasionally done), seems entirely indefensible.

The Roach Attachment[1] *No* 1.—The well-known Roach retainer consists of a split-tube slipping over a ball (Fig. 295). The contact of the two elements being the line around the circumference of the ball, only this retainer may be set with quite sufficient parallelism without the aid of special "jigs." The action of the Roach retainer is purely tenso-friction, and it also allows for "settling" without placing an undue strain upon the tooth or teeth involved. Carefully placed in the central position in the embrasure (Fig. 296), in combination with similar or other means of both direct or indirect retention, many combinations may be obtained, as will be noted in the text which follows.

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[1] The word "attachment" has heretofore been used in an indiscriminate sense. Here are three meanings in prosthetic dentistry:

(*a*) That part of the denture joining the teeth to the base and other parts (see Chart 3 and Fig. 260).

(*b*) A device for retaining, or retainer, as the Roach attachment (the original meaning).

(*c*) A flexible connector, as the Dresch attachment (Fig. 309).

In this chapter the meaning of the word attachment will be limited to the original, namely, that part of the denture joining the teeth and other parts of the denture to the base.

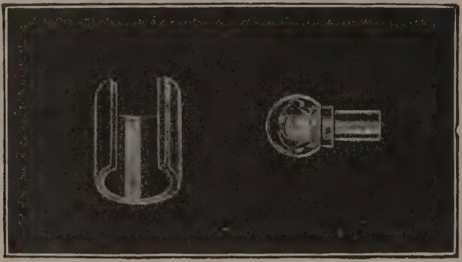

Fig. 295.—Roach retainer No. 1. (Wilson.)

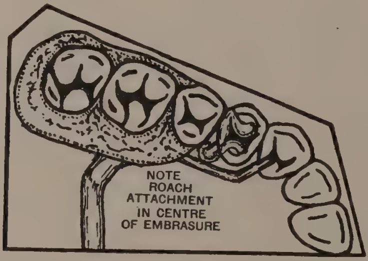

Fig. 296.—Showing proper location of Roach retainer (or attachment) in center of embrasure.

Roach Retainer No. 2.—As seen in Fig. 297, the new device is similar to the original, as set forth in the literature accompanying it:

"The newer (No. 2) style is simpler in practice because the tube, contact-spur, and anchorage-lug are all made from a single piece of clasp metal at our factory, and, in that form, obviates the necessity of building up this part of the attachment in the laboratory. No. 2 is, by reason of its flatness, more compact, and is better, for this reason, in many cases. In addition, the button of the newer form, carrying as it does a wide flattened base, is much easier to solder, and the union tends to be more secure. The choice of the best style to use must, of course, be left to the judgment and experience of the operator."

In addition to this, due to its smaller size, the button may be reversed and recessed in the inlay (Fig. 298, *B*).

It may be noted in passing that the Roach retainer No. 2, approaches very closely the class of the precision direct retainers, and must be handled with great care as to parallelism of the elements and general accuracy of technic. As such, its use is practically limited to root-supported partial dentures.

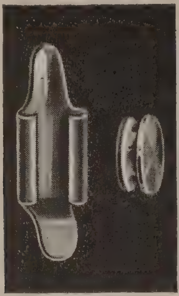

Fig. 297.—Roach retainer No. 2.

Single Stud.—A stud is a positive retaining device, usually used in conjunction with other retaining devices located on the opposite side of the mouth, and consisting of a projection of slightly inverted cone-shape of about 14-gauge (Brown and Sharpe), and about 3 mm. long, which engages in a recess in an inlay, crown, bridge, pontic or similar device (Fig. 299). It is usually used with dentures restoring teeth on one side only and in conjunction with a rest or indirect retainer, and is made to engage in a horizontal direction in the hole or recess, while on the other side of the mouth other attachments, such as clasps or

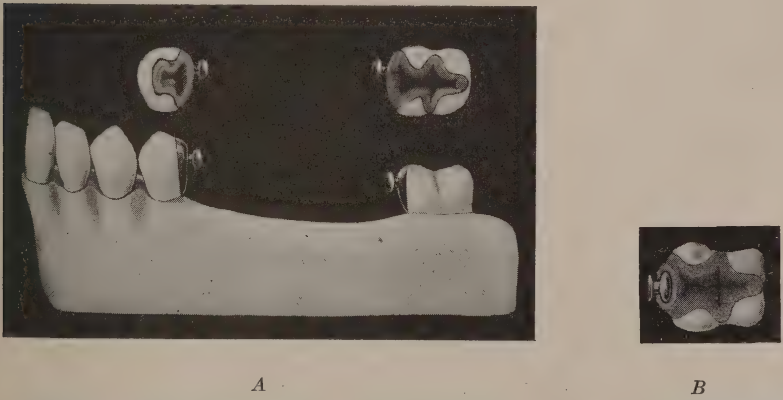

Fig. 298.—Roach retainer No. 2. *A*, buttons soldered to inlay to the lingual of contact point. It is sometimes possible and desirable to reverse the retainer, embedding the tube in the inlay. This plan still further lessens the interference of the retainer to the first tooth to be put on the plate. (See small cut, *B*.)

Roach retainers, are employed, permitting the saddle to slip home in a vertical direction. The removal of the piece is accomplished in reverse order, as it may be pulled away vertically and then horizontally, thus disengaging the stud.

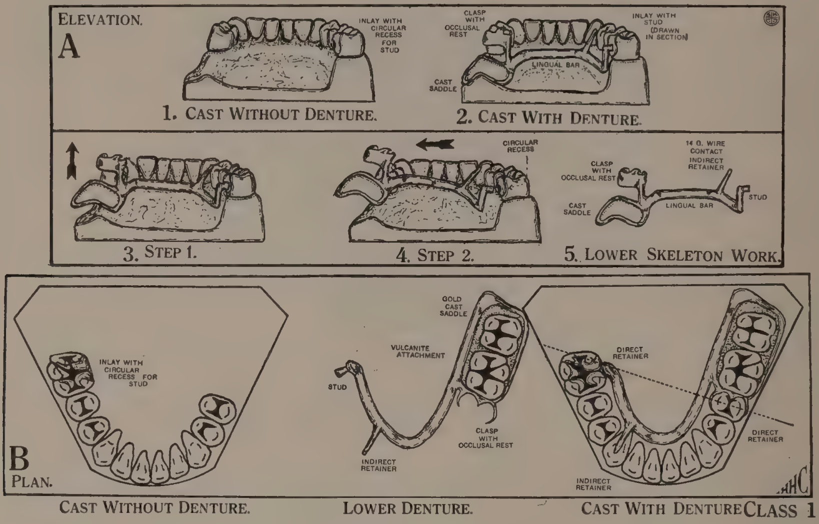

FIG. 299.—*1*, *2*, framework in position; *3*, first step in removal, clasp raised; *4*, second step, clasp free of bicuspid, piece moved laterally disengaging stud; *5*, metallic framework. (N. B.—Insertion done in reverse order, stud placed first, then clasp.) *B*, plan of restoration.

Ring and Stud.—In certain cases, such as those in which retention is desired on a shell crown, half hood, or similar comparatively thin covering on the lingual side of a tooth, the process may be reversed and a stud soldered to the crown, and in this stud a ring may be engaged.

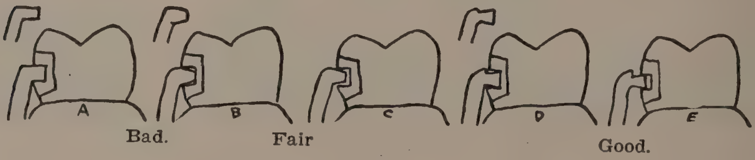

FIG. 300.—Proper shape of stud. *A*, cylindrical stud closely fitting a cylindrical hole does not allow other side of denture to pass other retainers without dislodging inlay; *B* and *C*, cone-shaped stud (only fair as allows play when stud is not perfectly seated); *D* and *E*, inverted cone form, good (no play in any position of stud).

This has an advantage also in the case of elderly persons and persons of poor sight, enabling them more easily to "find the place," but should not be used on small inlays, as the dislodging influence from leverage may be too great (Fig. 300).

Double Stud.—In occasional cases studs may be opposed to one another to advantage, the appliance being removed by springing the studs together, thus releasing the piece. A very good example is a simple retainer for an obturator (Fig. 302), in which two inlays with recesses were made on the lingual sides of both the upper first molars and an arch of 14-gauge wire rolled slightly flat and terminating at each end with a stud, and with mesial and distal rests to prevent rotation. This springs in and out, providing a very satisfactory attachment for an obturator, with the cutting of only two inlay cavities on the lingual sides of the upper first molars.

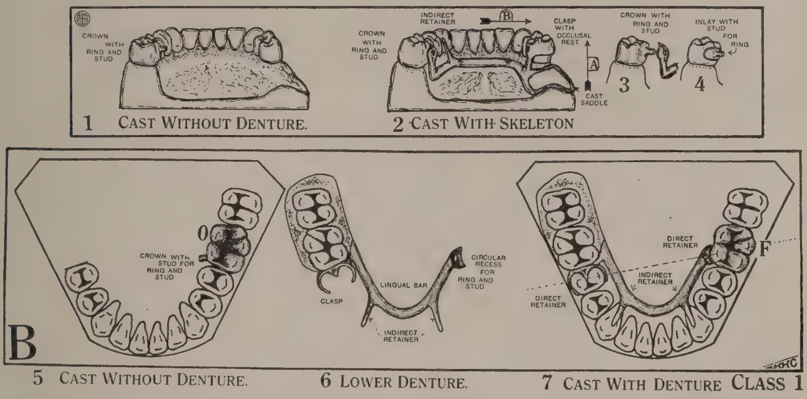

Fig. 301.—Reverse of Figs. 299 and 300. Stud soldered to crown, *B*, and recess for this in a ring, mounted on framework. Care should be taken in scoring both inlay and cavity immediately prior to cementation.

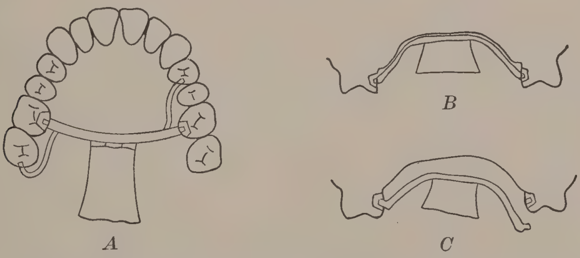

Fig. 302.—Showing use of the double opposed stud in an obturator frame. Two inlays with circular 14-gauge recesses are made for the lingual surfaces of the molars. A piece of flattened 14-gauge platinum and gold wire is arched across the palate, *B*, and armed at each end with a stud; upon this is attached the obturator hinge. The piece is removed by springing one of the studs lingually, *C*, in releasing the piece, and the insertion is accomplished in reverse order, one stud engaged first, then the other sprung into position.

Double Opposed Ring and Stud.—The ring and stud may be used in place of the opposed stud. Fig. 303 shows the application. If uncut

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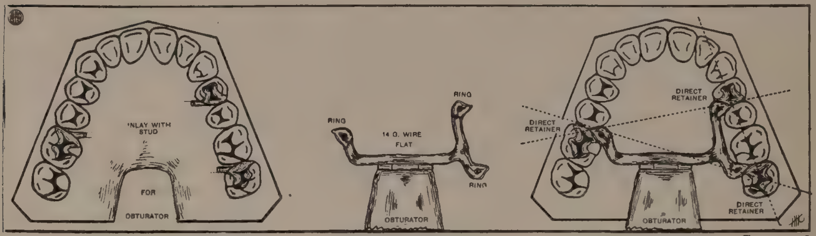
teeth are to be used for inlays, an advantage exists here, inasmuch as the depth of the inlay need not be as great as in Figs. 299, 300 and 302. Care must be taken to score the inlay and cavity immediately prior to cementation.



CAST WITHOUT DENTURE. UPPER DENTURE. CAST WITH DENTURE CLASS 4

FIG. 303.—Showing the use of double opposed ring and stud in support of obturator.

Methods of Increasing Fixation of Inlays Which Are Part of Direct Compound Retainers.—In the simpler forms of inlays, the placing of opposed grooves in the inlay against opposite opposed grooves made in the cavity after withdrawal of wax gives a very decided element of strength against dislodging stresses (Fig. 304). In the compound forms the use of one, two, and sometimes three pins of 20-gauge metal, located in suitable positions, subsequently threaded to be received into holes, also threaded, is an additional advantage. In the M. O. D. forms of cavities the opposed groove and occasionally pins and diagonal tapered locking pins materially assist (Fig. 304). The necessity for devitalization in these instances is largely a matter for separate consideration, depending on such conditions as age, history of pulp behavior, roentgen-ray information, amount of caries, amount of stress to be borne and similar considerations. When more extensive preparations involving pulp destruction are necessary, the condition appears to be more properly embraced in crown and bridge science rather than prosthetic dentistry. For inlay with dowel, half-hood with dowel, and similar preparations, a locking screw made from the well-known Blue Island screw post and accurately fitted after cementation, mechanically provides against movement in the only remaining direction of egress (Fig. 305).

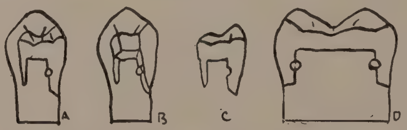


FIG. 304.—*A*, *C*, *D*, showing (in section) use of opposed grooves in inlays. Note that, in order to remove these inlays, the rod of cement between these opposing grooves must be sheared. Shearing is one of the strains to which the cement is most resistant, so that, in this instance, the adhesion-cohesion of the cement which retains the inlay is enormously supplemented by rods of cement which practically lock the inlay in position.

Indirect Retention.—It may be noted that all retaining devices previously described in this chapter exert their retaining function directly upon the tooth or teeth to which they are attached.

In, for example, Fig. 306, Section 2, it will be seen that an extension is carried forward to the cuspid. Without this extension it may be well imagined that difficulty would occur in retaining the most remote part of the denture, namely, the distal end of the saddle. Should the retainer grasp the bicuspid sufficiently for adequate retention, there is a danger that the bicuspid would, during mastication, be subject to *torque* similar to that described in Figs. 322 and 323 with accompanying text. With the extension, however, as shown in this figure, and in the lower drawing, in Fig. 306 (which is a diagrammatic lingual elevation of this restoration), it may be seen that, if the saddle tends to drop at its distal part, it is checked by the contact of the indirect retainer at the cuspid. The work (retaining the saddle), coming from the power (the contact of the indirect retainer upon the cuspid), through the fulcrum (the direct retainer on the second bicuspid).

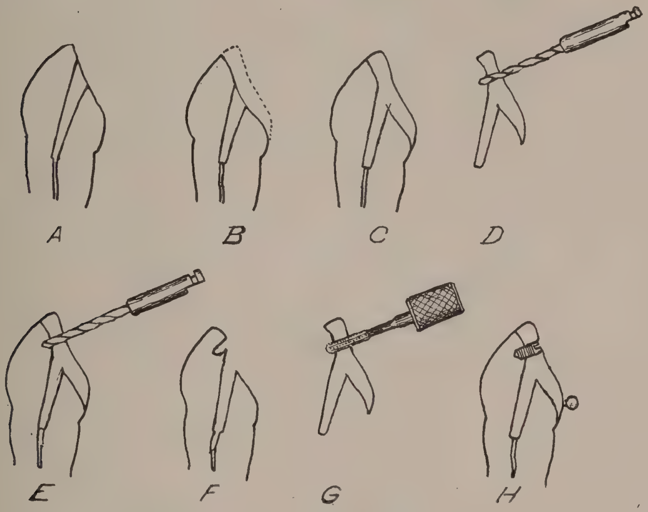


Fig. 305.—Steps in construction of lock screw, using inlay and dowel as example. *A*, preparation complete; *B*, wax pattern and dowel fitted; *C*, inlay; *D*, hole for locking screw; *E*, hole for locking screw in tooth, drill guided by hole in inlay already made; *F*, hole in tooth enlarged; *G*, inlay being tapped; *H*, locking screw in position turned permanently home before the cement has set

It may be noted that the rationale is a modification of the lever of the first class in which, in this particular instance, the power is likened to the rest which is in contact only with (not pressing on) the cuspids; the fulcrum, to the Roach retainers; and the tooth, to the resultant force which holds the piece in its position (Fig. 306).

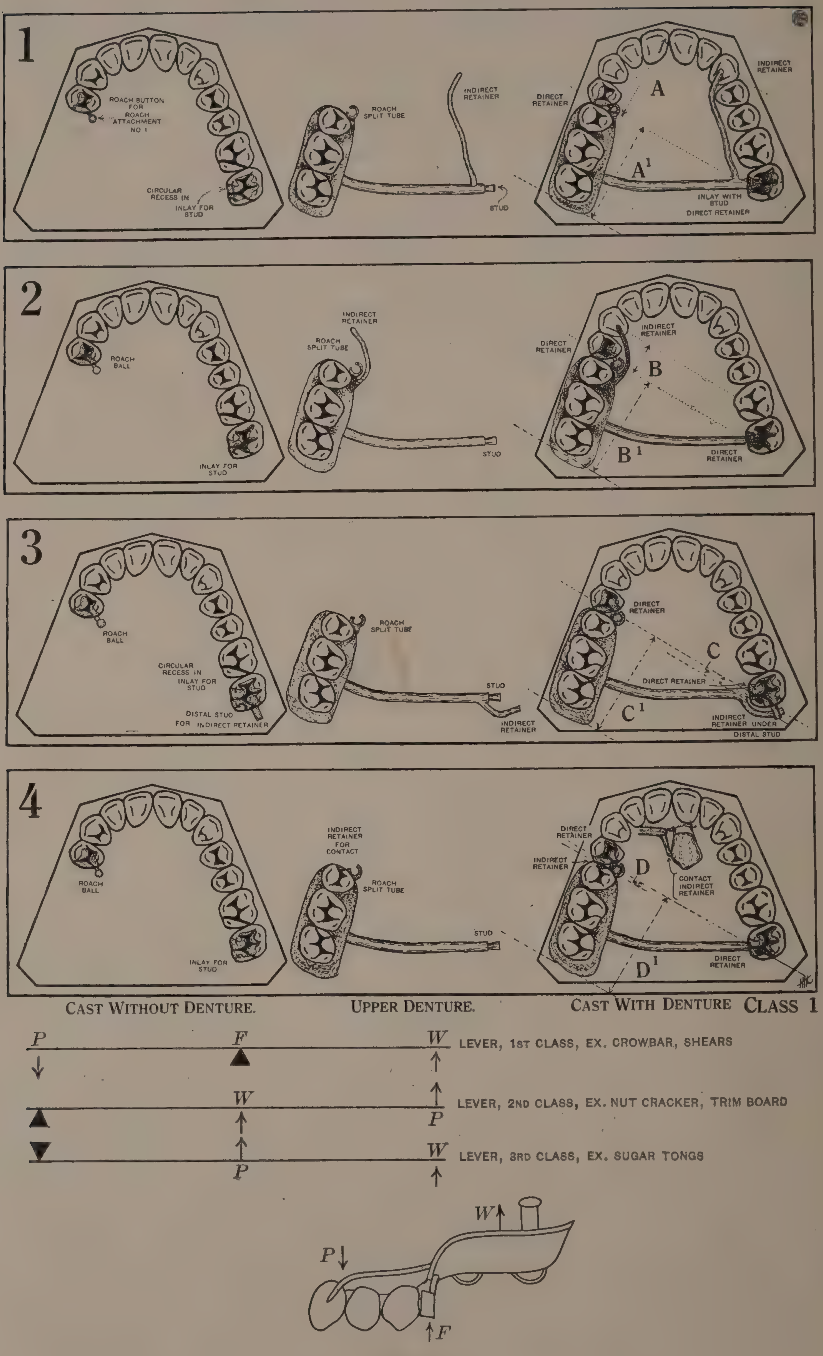
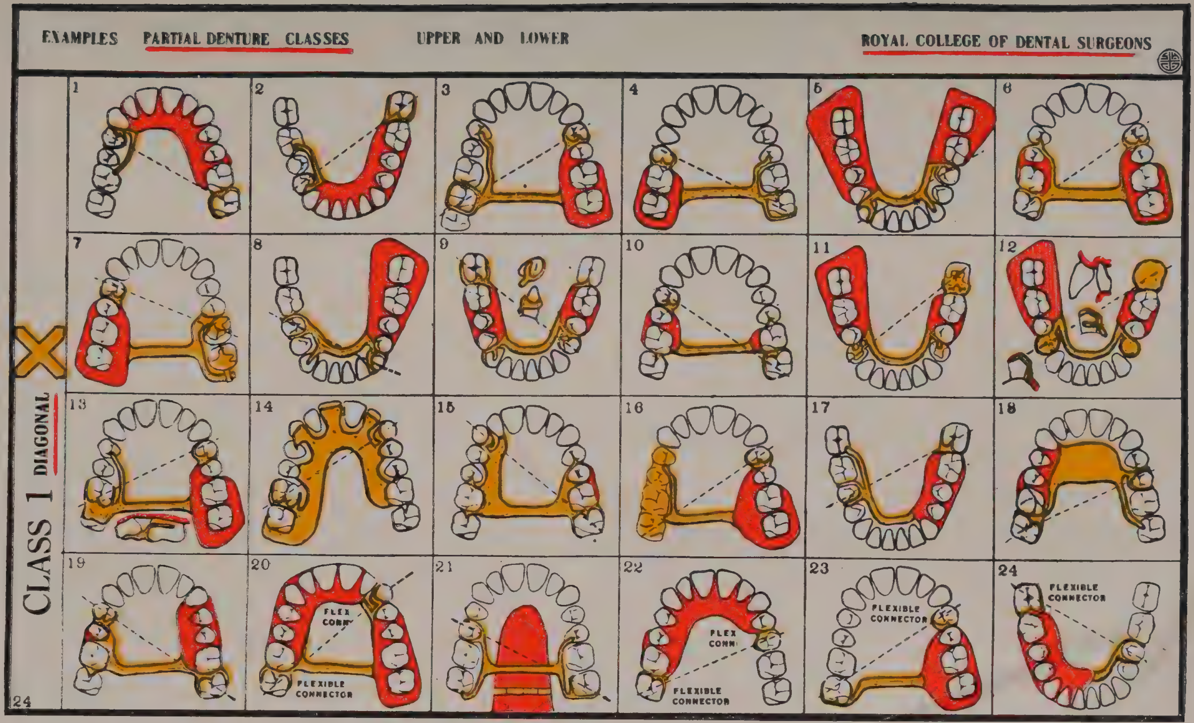

1
ROACH BUTTON FOR ROACH ATTACHMENT NO 1
CIRCULAR RECESS IN INLAY FOR STUD
ROACH SPLIT TUBE
INDIRECT RETAINER
STUD
DIRECT RETAINER
A
A1
INDIRECT RETAINER
INLAY WITH STUD
DIRECT RETAINER
2
ROACH BALL
INLAY FOR STUD
INDIRECT RETAINER
ROACH SPLIT TUBE
STUD
DIRECT RETAINER
INDIRECT RETAINER
B
B1
DIRECT RETAINER
3
ROACH BALL
CIRCULAR RECESS IN INLAY FOR STUD
DISTAL STUD FOR INDIRECT RETAINER
ROACH SPLIT TUBE
STUD
INDIRECT RETAINER
DIRECT RETAINER
C
DIRECT RETAINER
C1
INDIRECT RETAINER UNDER DISTAL STUD
4
ROACH BALL
INLAY FOR STUD
INDIRECT RETAINER FOR CONTACT
ROACH SPLIT TUBE
STUD
DIRECT RETAINER
INDIRECT RETAINER
D
CONTACT INDIRECT RETAINER
D1
DIRECT RETAINER
CAST WITHOUT DENTURE.
UPPER DENTURE.
CAST WITH DENTURE
CLASS 1
P
F
W
LEVER, 1ST CLASS, EX. CROWBAR, SHEARS
W
P
LEVER, 2ND CLASS, EX. NUT CRACKER, TRIM BOARD
W
P
LEVER, 3RD CLASS, EX. SUGAR TONGS
W
P
F

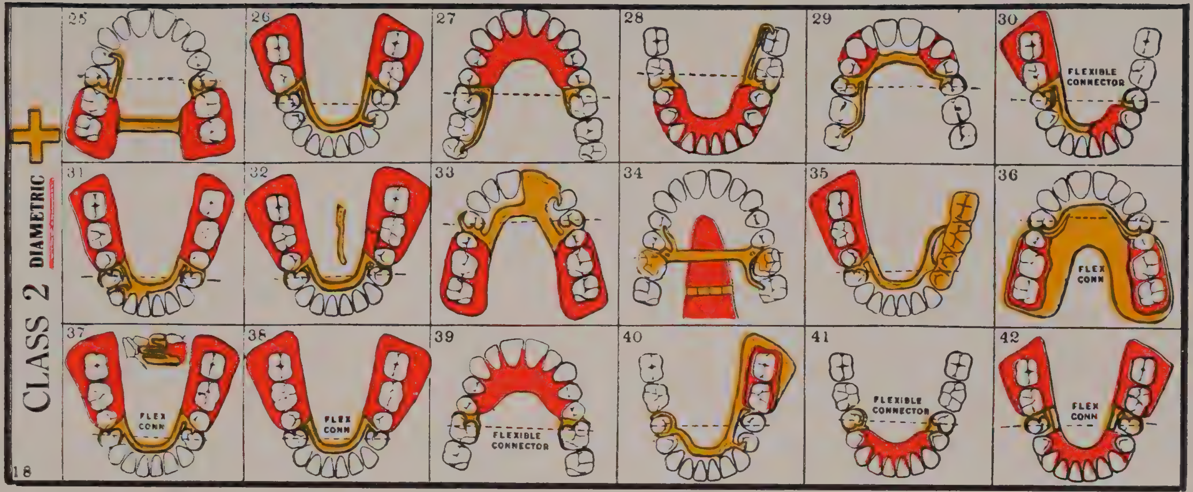
FIG. 306

PLATE I



Examples of the diagonal class of partial dentures in which indirect retention is here shown in various applications, but in all cases in connection with direct retainers which are diagonally opposite. It must be borne in mind by the reader that all of the above restorations may be subject to modifications through variations in local oral conditions not possible to describe here.

PLATE II



Examples of the diametric class of partial dentures in which indirect retention is here shown in various applications, but in all cases in connection with direct retainers which are diagonally opposite. It must also be borne in mind by the reader that all of the above restorations may be subject to modifications through variations in local conditions not possible to describe here.

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Indirect retention, therefore, may be spoken of as the utilization of a force (*P*) remote from that part of the denture to be retained, between which another of the direct forms of retainers is interposed (*F*), the resultant force (*W*), tending to seat the saddle more firmly in position. This scheme or system of retention may be used in a great number of modifications, and is specially useful in unilateral cases with retention for the saddle at one end only, as in Fig. 306.

It would appear at first glance, taking Fig. 306, Section 2, as an example, that the indirect retainer resting upon the sloping lingual surface of the cuspid might act as an inclined plane and move this tooth labially as an orthodontia appliance. The indirect retainer must be in contact with the cuspid, and nothing more; so that, taking the fulcrum line as the balancing line, the upward thrust of the indirect retainer would equal the weight of that part of the partial denture on the opposite side of the fulcrum line to the indirect retainer *minus* the tenso-friction in the direct retainer; which results in a negligible quantity. In fact, if there were pressure rather than contact in this case, the result would likely be that in a day's time the distal part of the saddle would be pressed up so hard that there might be an injury done to the mucosa at this point.

In order, however, to provide a wide margin of safety, the writer recommends that indirect retainers be not applied singly to central or lateral incisors, upper or lower.

Indirect retention is not necessarily applied in all cases to the surfaces of teeth. Under favorable circumstances indirect retention may be derived from saddles which are made to rest on the mucosa, as in Square 20, Plate I, and Squares 30, 36 and 42, Plate II.

Classification of Restorations, Based on Retention, and the Characteristic Variations of the Indirect Retention to Secure Balance.—A classification is useful when, in the grouping together of the various examples

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Fig. 306.—Indirect retention. Upper drawing, Sections 1, 2, 3, 4 indicate various positions of an indirect retainer as considered in the text. The distance between the fulcrum line and the indirect retainer, and the distance between the fulcrum line and that part of the denture most remote from it, should equal one another, if possible. Referring to the upper drawing, Sections 1, 2, 3 and 4, it will be noted that, in the same case, these first-named distances (marked *A*, *B*, *C*, *D*) progressively diminish, and with it the indirect retention afforded.

Also, there is a difference in the reaction against the cuspid carrying the indirect retainer. This may be explained by comparing Section 1 with Section 2. In Section 1 distance *A* and A^1 are equal, so that the reaction against the cuspid would be the weight of the denture minus the tenso-friction on the direct retainers. In Section 2, however, the distance *B* is approximately one-third of the distance B^1. Hence the reaction against the cuspid is multiplied by 3 minus the tenso-friction.

In this particular case this is still negligible, and perhaps desirable, because the denture in Section 2 is smaller and more compact than the one in Section 1.

In Sections 3 and 4, however, the leverage is somewhat undesirably great, especially in 4, in which the upper right first bicuspid has the double duty of supplying direct as well as indirect retention.

The lower drawing illustrates that indirect retention is an application of the first class lever, as also described in the text.

of a class, similarities and dissimilarities may be pointed out which simplify the problem.

The classification here proposed is that of finished restorations rather than that of unrestored conditions,[1] and is based primarily upon the position of the direct retainers, and secondarily upon the position of the indirect retainers (in the first two classes only).

The hypothesis is that all partial dentures may be divided into four different classes as follows:

1. × Diagonal: Direct retainers (two in number) diagonally opposite.
2. + Diametric: Direct retainers (two in number) diametrically opposite.
3. ⊓ Unilateral: Direct retainers (two or more in number) on same side.
4. △ Polylateral: Direct retainers (three or rarely four) in a triangular (or rarely, in quadrilateral) relationship.

The First or Diagonal Class of Partial Dentures and the Fulcrum Lines as an Indication of these Classes.—A study of Plate I, with twenty-four restorations, will first show that all of the examples carry a dotted line which passes approximately in a diagonal and central position upon each denture (including natural and artificial teeth). This dotted line joins the two direct retainers, which is the number of direct retainers peculiar to this class of denture, as indicated by the position of the direct retention in the denture. Prothero has called this line the fulcrum line.[2] In this class the fulcrum line passes diagonally across, which is the basis of the first or diagonal class.

Another noteworthy phase may be pointed out which will assist in the choice of design of indirect retention. In the examples in Plate I if a line be drawn from that part of the partial denture furthermost from the direct retainers to the point of application of the indirect retainer, it will be found that this line crosses the fulcrum line at right angles, making a diagonal cross. For this reason the sign × is chosen as representing the first or diagonal class of partial dentures. As noted in Fig. 306 the denture should be as nearly in balance as possible, as considered in the legend under this figure.

The Second or Diametric Class of Partial Dentures .—A study of Plate II, showing eighteen restorations, will also show the fulcrum line passing diametrically across each denture, including both natural and artificial teeth. In the examples in Plate II, if a line be drawn from that part of the partial denture furthermost from the direct retainer to the point of application of the direct retainer, it will be found that this line crosses the fulcrum line vertically. For this reason the sign + is chosen as representing the second or diametric class of partial dentures.

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[1] A classification of unrestored conditions is proposed by Dr. Edward Kennedy, New York (Items of Interest, January, 1925, p. 23).

[2] Prothero's Prosthetic Dentistry, p. 247.

The Position and Adjustment of Indirect Retention.—From the foregoing, the position of the indirect retainer, if chosen for retention, may easily be determined, namely, at a general position opposite to that part of the partial denture least supported by the direct retention, between which two positions the fulcrum line passes. From the general position a tooth is chosen, which may be any tooth except a central or lateral incisor, but preferably one in which the occlusion permits the indirect retainer to be applied to an occlusal surface. The indirect retainer should be adjusted so that there is no pressure, but only contact, and should pass to the tooth chosen from the nearest part of the denture using any depression, as rugæ, in which its presence would be least noticeable. It should not, as a rule, be led into the gingival margin (Fig. 307). In addition to this, it is desirable, if not always necessary, to have the indirect retainer and that part of the denture furthermost distant from the direct retainers as nearly as convenient equidistant from the fulcrum line. Fig. 306, Sections 1, 2, 3, 4, shows a series of variations in position of this distance in which 1 is, upon this basis, given the most, and 4 the least, favorable balance. It must always be remembered, however, that these forces are small and are under adverse conditions, but the weight of approximately half the denture, minus the tension friction in the direct retainers.

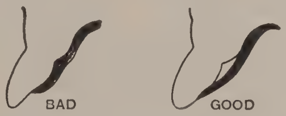


FIG. 307.—Indirect retainer should not be fitted into, but over the gingival margin.

The Contacts in Indirect Retention.—In Chart 4 is shown the main subdivision of the contacts used in indirect retention are as follows: (*a*) Contact only; (*b*) carrying the stress of mastication, both of which are subdivided as surface and recessed. For surface contacts half-round or round wire 14-gauge (B. and S.) may be used, either wrought or cast and may be designed as shown in Fig. 312. Numerous examples may be seen in Plates I and II.

Recessed contacts are those which because of such reasons as lack of space and similar reasons, are recessed in a crown, bridge or inlay. While no specific examples of recessed indirect retainers carrying no stress of mastication are shown, yet in Plate I, Squares 1, 2, 3, 4, 13, 17 and 18 what may be considered similar cases, showing the indirect retainer recessed in an inlay. The advantage of recessed indirect retaining contacts may readily be seen. The indirect retainers carrying the stress of mastication will be considered under Occlusal Rests, with which they are identical. Plate I, Squares 6, 9, 10, 11, 12, 14 and 15, shows examples of these.

- *Indirect retainers* (Classes 1 and 2 only)
  - Contact only
    - Surface
      - 1. 14-gauge wire (rounded).
      - 2. Cast.
    - Recessed
      - 1. 14-gauge wire obliquely recessed in inlay or similar.
      - 2. Cast to fit oblique recess.
  - Carrying stress of the teeth and mastication
    - Surface
      - 1. Various occlusal rests and pads, partial, full or multiple.
      - 2. Right ⅔ loop, M.D., B.L., L.A.
    - Recessed
      - 1. 14-gauge oblique wire recessed in inlay or similar.
      - 2. Casting oblique recessed in inlay or similar.

CHART 4.—Diagram of the contacts used in indirect retention, as subdivided in Chart 3, from which the above is produced.

The Two Remaining Classes which use Direct Retention Only.—These are the third or unilateral class, in which the retention is, from the number and position of the remaining teeth, derived from teeth on one side only; and the fourth of polylateral class, using out of necessity three or more direct retainers. Examples of these may be found in Plate III.

Connectors.—Connectors have been defined as those parts of a partial denture which join the base to the retainers or to the occlusal rests.

- 5. *Connectors*
  - 1. Rigid
  - 2. Flexible
    - 1. Simple
      - 1. Grasshopper.
    - 2. Compound
      - 2. Butterfly (Fig. 308).
      - 3. Dresch (Fig. 309) and various other similar devices.

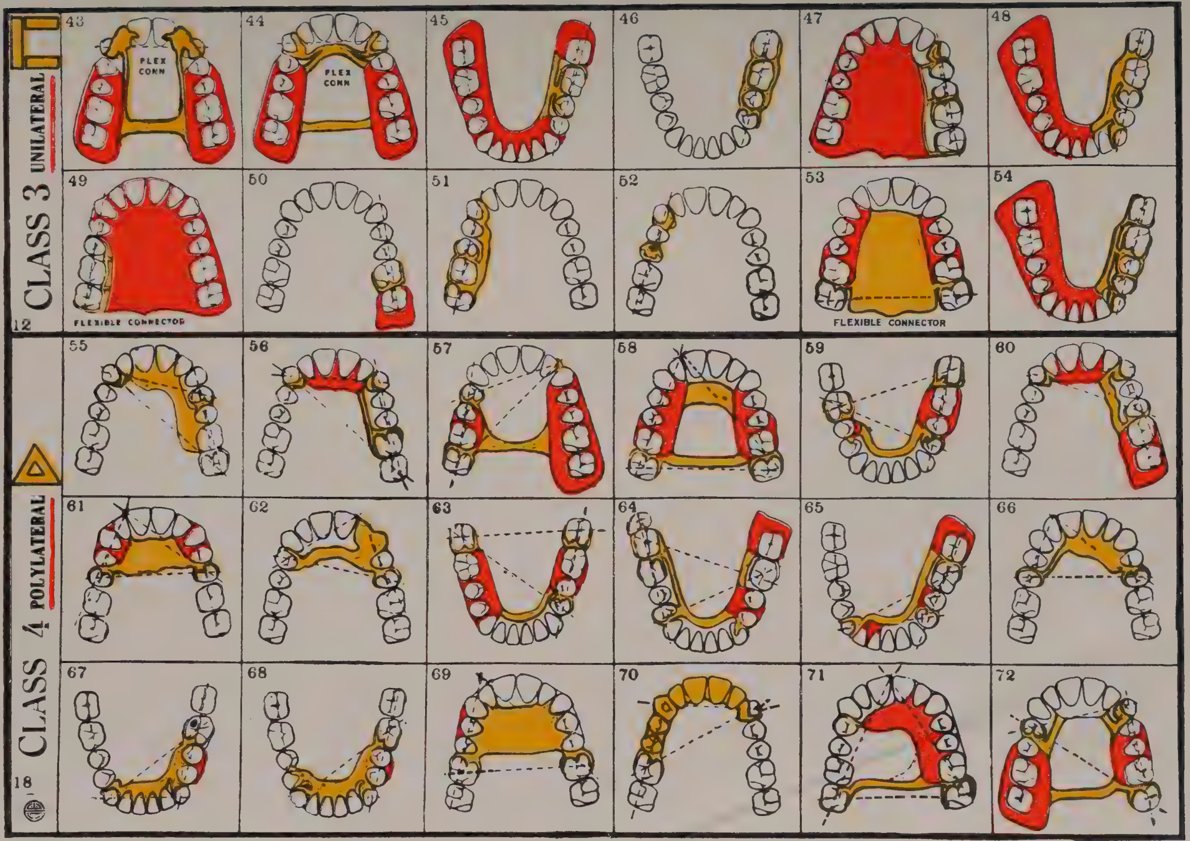
CHART 5.—Diagram of connectors used in partial denture service, and their subdivisions as seen in Chart 3, from which this is reproduced.

The rigid connector is used for this purpose in cases in which it is desirable to transmit the load of mastication to the remaining teeth, or to divide the load between the remaining teeth and the mucosa. Examples of the former are found in Plate III, Squares 46, 51, 59 and of the latter in 57, 58, 66 and 69. In its construction approximately 14-gauge round section, wrought or cast, may be used. The connectors should occupy a position in the center of the embrasure, and should be attached to the body of the clasp in order that the resiliency of the arms may not be interfered with.

In cases in which it is desired to relieve the retaining natural tooth from all except the minimum of the additional stress involved in retention, a flexible connector may be used. Other indications for these are all cases in which mucosa support is indicated, cases of a lack of bone or of any other adverse condition of the retaining teeth; and for saddles upon a less dense and consequently reduced mucosa in which the saddles would move greatly in excess of the slight motion of the natural teeth.

Flexible connectors are formed from elastic wire of various forms (Chart 5) and are also manufactured for the use of the profession,

PLATE III



Examples of the unilateral and polylateral classes. It must again be borne in mind by the reader that all of the above restorations may be subject to modifications through variations in local conditions not possible to describe here.

usually of an interlocking type of two parts. The Dresch flexible connector or stress-breaker, so-called, is a well-known example of the latter.

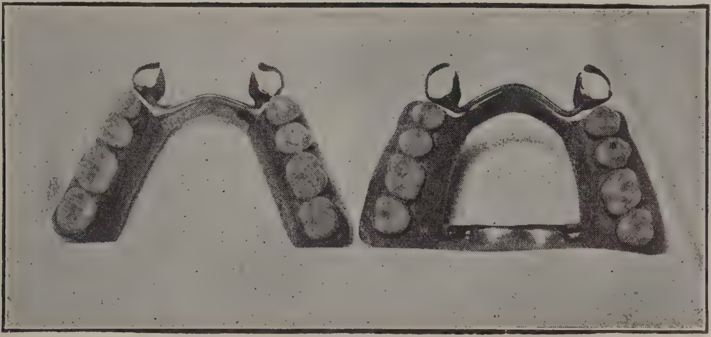


Fig. 308.—A simple flexible connector (W. A. Giffen) of 18-gauge elastic wire. An independent saddle movement is here secured, but without support from adjacent teeth. This type is occasionally referred to as "butterfly."

Occlusal Rests.—Contrary to the flexible connector stress-breaker, the occlusal rest is used in the main for transmitting stress to the remaining teeth. In many instances, in which partial restorations are required, the occlusal surfaces of the remaining upper and lower teeth approximate one another very closely because of wear and other natural causes, and entirely prevent the use of surface occlusal rests of any type. In instances of this kind, it would seem that cutting of tooth tissue to the extent of preparing an inlay sufficiently large to permit a recess for the engagement of a 14-gauge occlusal rest in its surface is quite unavoidable inasmuch as surface occlusal rests require a thickness of at least 16-gauge (B. and S.) (see Fig. 310), at a point immediately over the marginal ridge. Only in instances in which

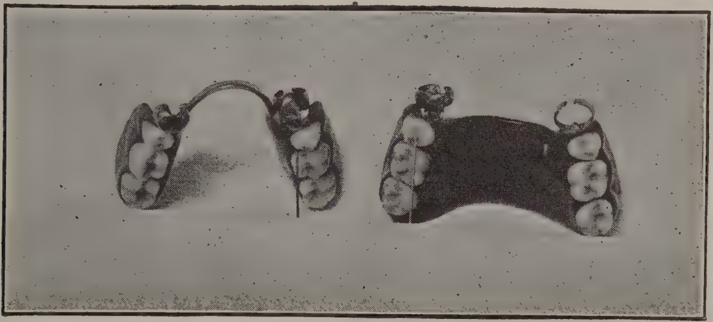


Fig. 309.—A compound flexible connector. (Dresch.)

it is impossible to secure this space by removing enamel from the marginal ridge and from the opposing cusps, is an inlay preparation indicated. These inlay preparations require well-defined angular definition in their various line-angles, and a removal of tissue on the lingual side to permit the reception of a 14-gauge occlusal rest preferably in an oblique direction through the embrasure. Fig. 310 illustrates an instance of this condition. Special attention is called to the rule relative to mesio-distal or diagonal entry of occlusal rests (see Fig. 315, *C*).

6. *Occlusal rests*
    - Recessed
        1. 14-gauge oblique wire.
        2. Casting.
    - Surface
        1. Quarter, half, full and multiple occlusal pads.
        2. Two-thirds rigid loop, mesio-distal, bucco-lingual, line-angle.
        3. Mesio-distal, bucco-lingual, line-angle, embrasure and other clasps, with sufficient material on occlusal cone.

Chart 6.—Diagram of the occlusal rests used in partial denture service and their subdivision, as seen in Chart 3, from which this is reproduced.

Forms of Surface and Recessed Occlusal Rests.—The general form of both surface and occlusal rests should be approximately horizontal at the point of entry at the marginal ridge, and following the sulcus should curve rootwise at least half its length so as to direct the resulting loads from mastication along the long axis of the natural tooth upon which it rests. Care should be taken to have a thickness of at least 16-gauge (B. and S.) immediately over the marginal ridge to avoid breakage at this point. Figs. 310 and 312 illustrate these points.

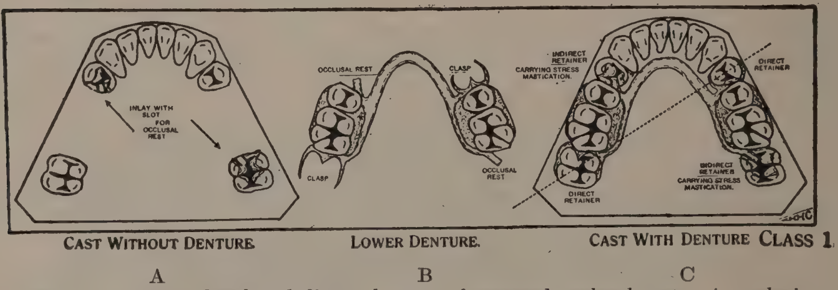

INLAY WITH SLOT FOR OCCLUSAL REST
OCCLUSAL REST
CLASP
CLASP
OCCLUSAL REST
INDIRECT RETAINER CARRYING STRESS MASTICATION.
DIRECT RETAINER
INDIRECT RETAINER CARRYING STRESS MASTICATION.
DIRECT RETAINER
CAST WITHOUT DENTURE
LOWER DENTURE.
CAST WITH DENTURE CLASS 1
A
B
C

Fig. 310.—Mesio-distal and diagonal entry of recessed occlusal rests. *A*, occlusion is close, without space for surface occlusal rest (inlays are, therefore, required for each occlusal rest and three-arm clasp, in which are recesses for the reception of the occlusal rests of 14-gauge elastic clasp wire); *B*, denture out of the mouth (note the diagonal entry of the occlusal rests on the left side of the cut and the mesio-distal entry of these on the right); *C*, comparison chart of diagonal and mesio-distal entry of occlusal rests (diagonal entry involves a larger cutting of the lingual wall of cavity, while mesio-distal entry greatly weakens the artificial tooth). These circumstances govern the choice between these entries.

With regard to recessed occlusal rests, reference to Fig. 315 will show that similar conditions govern this form of the recessed occlusal rests as to this surface.

Surface Occlusal Rests, Various Types.—It will be noted that in open occlusion, or occlusion which allows ample space for occlusal rests,

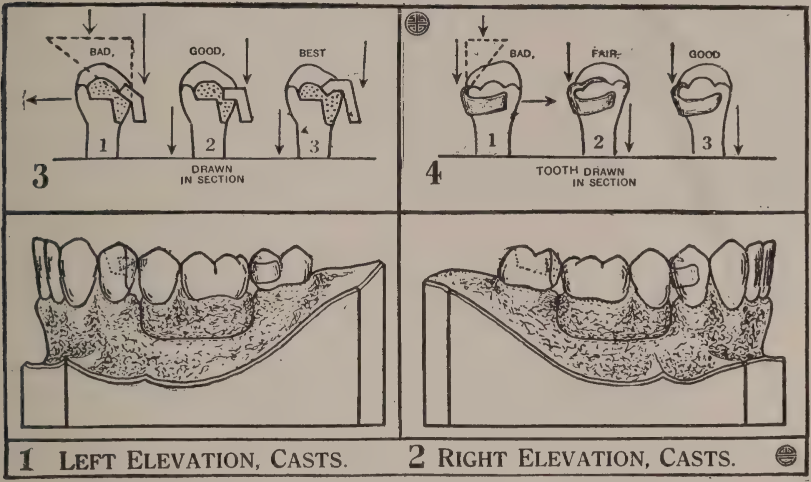


FIG. 311.—Recessed occlusal rests. Note in **3**, 1 and **4**, 2 inclined occlusal rests acting similarly to a wedge and in this case wedging the teeth apart; 2, a horizontal, mesio-distal section of correct and incorrect forms of surface and recessed occlusal rests, but 3, the hooked form, which is the safest.

Surface occlusal rests. Note that the first drawing, 1, shows an occlusal rest in contact with half the marginal ridge. Unless the arms of the clasp are very heavy this will also act as a wedge, and will, in this case, wedge the teeth apart. 2 is a better form, but covers an unnecessary amount of tooth surface, while 3 is proposed as correct.

NOTE I.—In each case the elevation of the case is shown, while in Fig. 310 is shown the plan.

NOTE II.—The drawing **4** shows the tooth only drawn in section, while the clasp is not drawn in section, which seems to more clearly show the meaning intended.

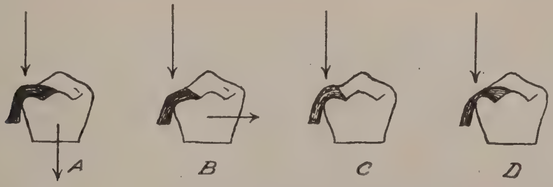


FIG. 312.—Sections of surface occlusal rests, showing proper form. *A*, correct form (except it is too long) of surface occlusal rest (horizontal and curving rootwise); resultant force applied to this tooth is a normal stress and resisted along the long axis of the tooth; *B*, incorrect form of occlusal rest (rootwise curve absent, and as a result stress drives the tooth forward, a trauma); *C*, correct thickness of occlusal rest at point over the marginal ridge (this is the point of most frequent fracture, and the thickness here should be at least 16-gauge in a surface rest); *D*, occlusal rest too thin. Note.—*A* and *D* project too far past the sulcus, covering tooth surface unnecessarily, with a danger of capillary retention of saliva with fermentable contents.

as hereinafter described (and which occurs with more or less frequency from the disturbance of position, and consequently of occlusion, due to the partial loss of teeth), surface occlusal rests are used. With regard to surface occlusal rests, Fig. 313 illustrates a simple occlusal sulcus rest which is embodied in this denture, made by burnishing pure gold and adding clasp metal as a solder.

Two instances of occlusal rests covering all or part of the occlusal surface of a tooth are given in Fig. 313. These are usually used to cover areas out of occlusion and to bring the opposing teeth into occlusion. *Particular care must be taken to avoid the use of these rests and pads, shown in Figs.* 313 *and* 314, *in mouths with any predisposition to caries. In such cases the teeth should be built up by inlays, crowns or similar restorations.*

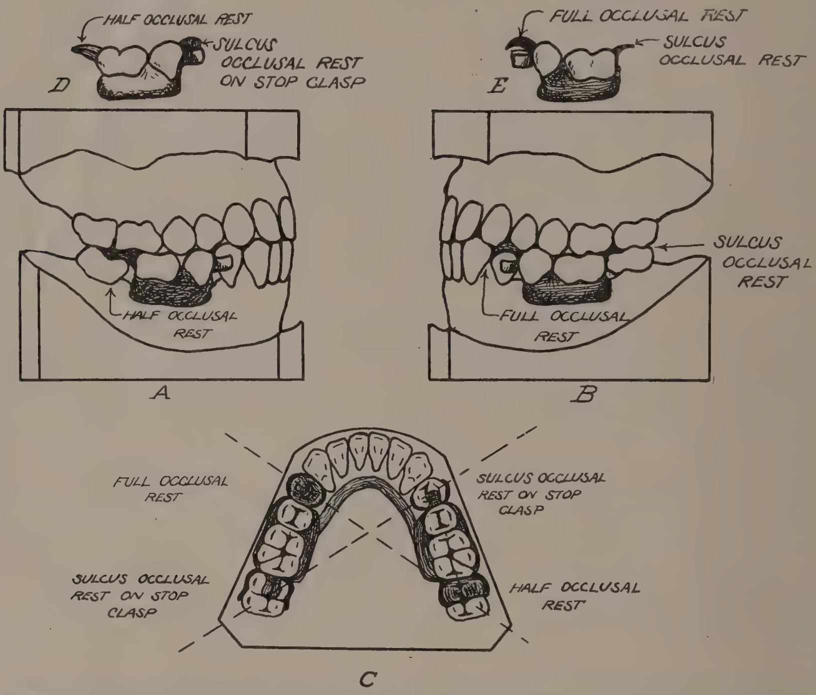


Fig. 313.—Showing instance in which large occlusal rests and pads are employed on a partial denture (which is used here instead of bridgework), and which restore a part in one instance, and the whole in the other, of the original masticating function without any cutting of tooth tissue. *A*, right lateral view of same condition (note tipped condition of second molar and loss of approximately one-half the occlusal surface); *B*, left lateral view of a condition in which second bicuspid and first molar are lost (note entire lack of occlusion of the first bicuspid); *C*, occlusal view of restoration (saddles supplying the teeth, three-arm clasps on one diagonal, occlusal rests on the other diagonal); *D*, right lateral view of the restoration (note restoration of occlusion); *E*, left lateral view of the restoration (note restoration of occlusion).

Caution.—This type should not be used when any predisposition to caries exists.

Various Positions of Occlusal Rests upon the Teeth.—In these studies, surface occlusal rests have been shown up to the present stage as covering the mesial or distal marginal ridge. Fig. 315 will show instances taken from practice in which, due to peculiar conditions of the occlusion, the occlusal rests have been used in other positions, largely due to lack of space.

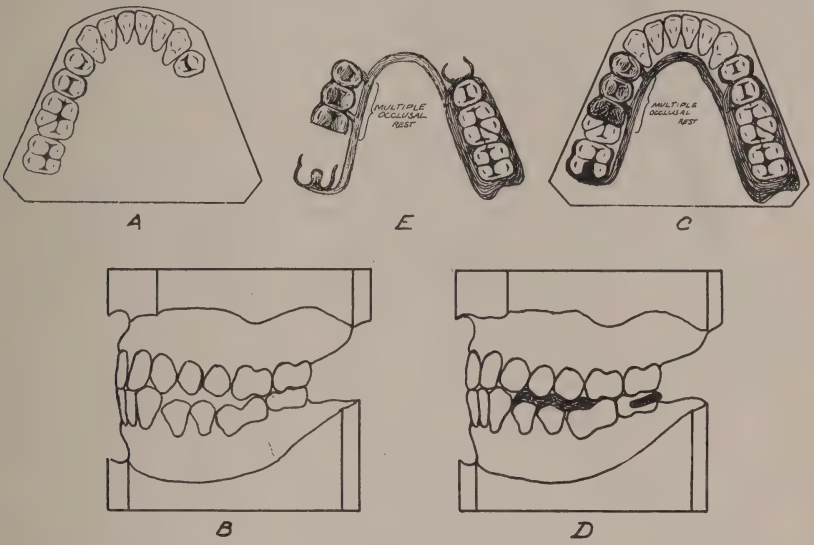


Fig. 314.—Showing an instance in which an occlusal pad (an occlusal rest) covering the occlusal surface of one or more teeth is used to supply a deficiency in the occlusion at a point remote from the space supplied by artificial teeth. This type of appliance is only indicated in cases in which there is immunity to caries. *A*, occlusal view of condition before treatment; *B*, lateral view of condition (note lack of occlusion due to fracture of the mandible; occasionally due to other causes); *C*, occlusal view of restoration; *D*, lateral view of restoration; *E*, restoration outside of the mouth.

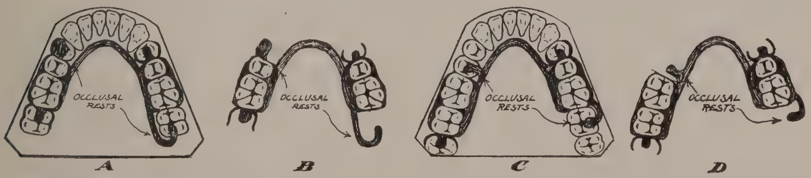


Fig. 315.—Occlusal rests placed in positions other than mesial or distal to endentulous spaces, by reason of lack of space in occlusion. *A*, occlusal rests covering entire buccal cusp of bicuspid on one side and entry on distal side of molar on other side; *B*, showing this restoration outside the mouth; *C*, surface occlusal rests with lingual entry on bicuspid and buccal entry on molar; *D* shows this restoration outside of the mouth.

Note.—The right distal occlusal rest at *B* embodies to a degree the principles of a flexible connector, because of the length of the connector or part joining the occlusal rest to the base.

Rigid Half-loop Occlusal Rests (Principally for Cuspids).—Frequently combinations of teeth, in and out, are encountered in which lower or upper cuspids are standing at the end of a space, in which the design indicates occlusal rest upon these teeth. A sulcus rest is impossible, due to the lack of sulci in the cuspids, and the use of a recessed indirect retainer involves considerable cutting of tooth structure. The half-loop occlusal rest made with non-resilient arms (usually cast) for these cases is admirably adapted to this peculiar situation, as instanced and briefly described (Fig. 316).

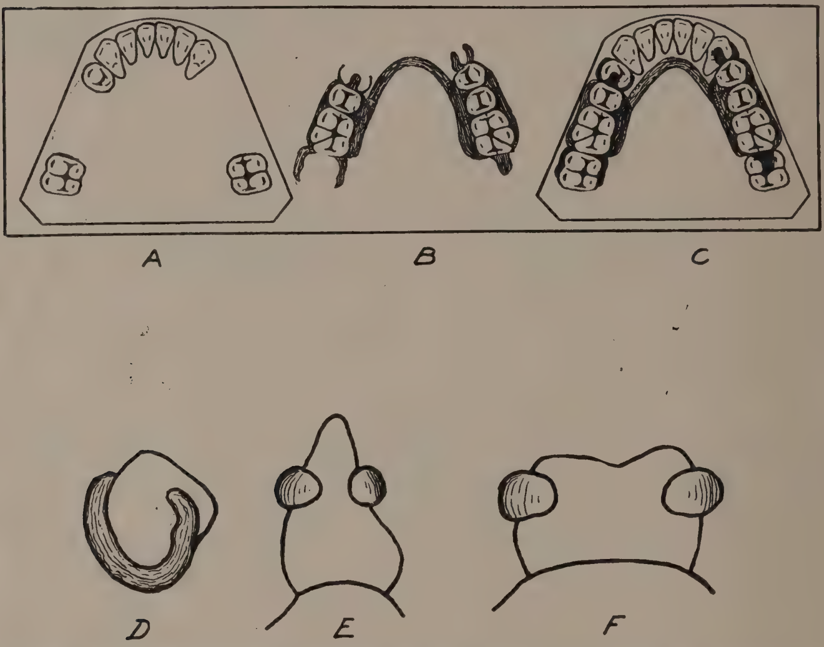


Fig. 316.—Showing the use of the rigid half-loop occlusal rest suitable for cone-shaped teeth in cases in which none of the foregoing occlusal rests are suitable, due to lack of occlusal surface or of space. *A*, an instance in which the above occlusal rest is indicated in a space with conical-shaped teeth occurring at the end (the cuspid shown at the right in the cut is required for support of the piece, and, due to the conical form of this tooth, this device is indicated; also the molar shown in the left side of the cut is also conical in shape, with tight occlusion; the use of the above device avoids unnecessary cutting); *B*, assembly outside the mouth; *C*, complete assembly (note the direct retainers, three-arm clasps, diagonally opposite with the rigid half-loop occlusal rests also disposed diagonally opposite); *D*, rigid half-loop as seen from the occlusal side (note that it is like a clasp, except that the body and arms are rigid, and that it is placed *occlusal* to the general line; and that the arms are carried sufficiently around the circumference of the tooth to result in these arms being at a lesser distance from one another than the central portion, preventing distal displacement); *E*, mesial view of cuspid (the rigid half-loop may be placed at any point upon the tooth above the line of widest cross-section); *F*, similar view of molar, to which a rigid loop is attached.

The Prevention of Injuries from a Lack of Partial Denture Service.—Fig. 317 shows that drifting, exfoliation, excessive stress, or wear and stagnation may follow the loss of teeth. This picture, while composite, is nevertheless real, and will assist the patient to realize the possible effects of an extensive loss of natural teeth without subsequent denture service.

C. Prevention.

5. Injuries as result of extraction preventable by good appliances
   1. Drifting.
   2. Exfoliation.
   3. Excessive stress and wear.
   4. Stagnation.

6. Injuries as result of *faulty* appliances preventable by *good* appliances (presupposing healthy mouth)

Structures.

1. Enamel, dentin and cementum, intensive caries production, erosion and wear, from capillarity.
2. Gingivæ: impingement and interference.
3. Mucosa and subjacent bone: overload.
4. " " " " strangulation.
5. Pericementum and mucosa, with subjacent bone: overload.
6. Pericementum: overload.
7. " torqued, vertical.
8. " torqued, horizontal.
9. " einclind plane (wedge), mesio-distal.
10. " inclined plane, bucco-lingual.
11. " inclined plane, mesio-distal and bucco-lingual.
12. " inclined plane, axial.
13. " lever 1st class (shears).
14. " " 2d " (nut cracker).
15. " " 3d " (flask tongs).
16. Pericementum, combinations of all mechanical advantages.
17. Dental pulp and periapical tissues, various injuries.
18. Cheeks, tongue and soft tissues, impingement and irritation leading possibly to malignancy.

Functions.

19. Mastication and ultimate digestion, various injuries.
20. Speech and voice, lisping, thick speech, etc.
21. Hearing, interference with.

Both structures and functions.

22. Any or all of above injuries, from lack of systematic maintenance.

CHART 7.—Diagram of the prevention of injuries, as taken from Chart 2.

The Prevention of Injuries from Faulty Denture Service—Caries Production from Faulty Clasps.—It is probable that no single agency has resulted in a larger loss of tooth tissue through dental caries than the imperfect clasp which is closely fitted about the gingival margin, as in Fig. 318.

In the greater number of anchor teeth to which clasps are fitted, these are either standing alone, or at the end of a series of teeth, immediately adjacent to which extraction and consequent resorption, with exposure of the cementum, have taken place. Such a clasp, fitted to the tooth with its gingival border in contact with the gingival margin, has the effect of holding a solution of food and saliva (the concentration of which depends largely upon the hygienic habit of the wearer) under conditions of warmth and moisture, which are ideal for bacterial action and consequent dental caries at this point. In addition to this, enamel protection is lacking, and this decomposing mass is held by capillary action directly against this part of the tooth least able to

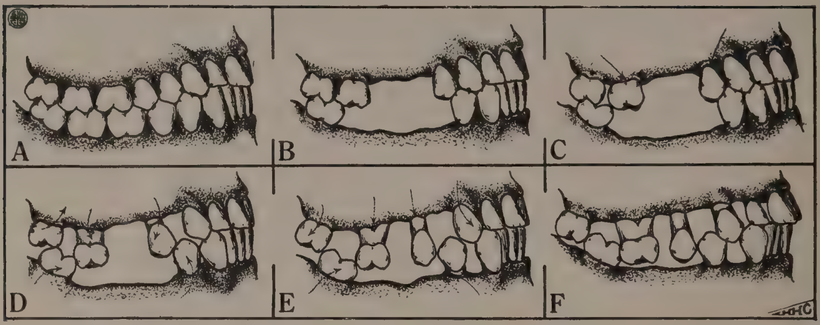


Fig. 317.—A diagram of malocclusion and loss of function which may occur following extraction under conditions of prior resorption or predisposition to periodontal disease—or from other causes, and which may be checked at any of the above stages by insertion of well-designed and executed partial denture. *A*, before extraction; *B*, immediately after extraction; *C*, lower molar drawn forward through cicatricial pull, upper second molar and bicuspid moving together through inclined planes in occlusion with lower (distance between jaws becoming slightly less, due to third lower molar carrying greater pressure and consequently more reaction from inclined planes; food packs between separated teeth aggravating conditions); *D*, upper bicuspids and molars driven further out of position by inclined planes and drifting (lower first bicuspid drifting distally from impact of inclined plane of upper cuspid; upper third molar wedged distally by lower third molar, intermaxillary space decreasing); *E*, lower second molar has wedged between the upper third and second molar, driving these apart (upper cuspid wedging between lower cuspid and lower first bicuspid, driving lower cuspid also forward and crowding the anterior teeth; food packs in spaces; intermaxillary distance decreasing); *F*, upper molars and bicuspids now touching lower ridge (lower anterior driving forward and spreading the upper anterior teeth; mastication now practically *nil* and painful).

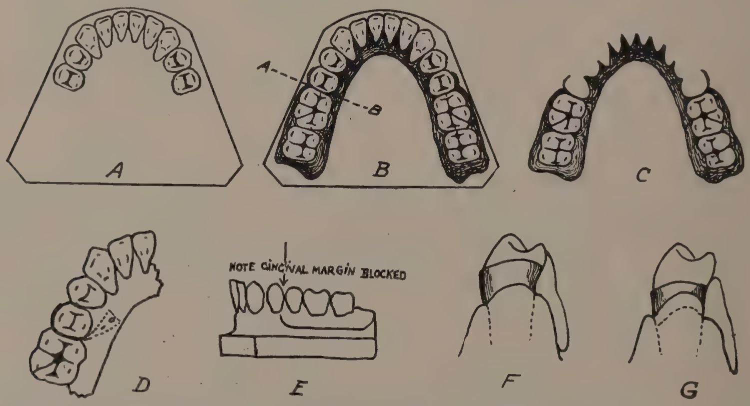


Fig. 318.—Detail of gingival irritating and caries-producing clasp. *A*, frequent condition requiring partial prosthesis (often at the distal surface of the bicuspid the cementum will be exposed above the gingival margin, due to resorption); *B*, faulty denture fitted to this case with faulty clasp, which is in contact with and irritating the gingiva, in addition to retaining by capillary action decomposing food against the cementum, causes caries; *C*, showing denture out of the mouth (note fitted parts of base against lingual aspect of teeth, producing gingival irritation and caries); *D*, showing details usually found in this type of clasp (the clasp is fitted against the buccal surface only, and base is carried high up on the lingual side, girdling the exposed cementum with decomposing food, and also irritating the gingival margin); *E*, buccal aspect of *B*, showing clasp partly covering enamel and partly covering cementum; *F*, diagrammatic view of clasp, tooth and gingiva at section *B*, *a–b; G*, showing the same clasp (to which an occlusal rest has not been fitted) settled and causing acute gingival interference in addition to caries.

resist caries. While this unfortunate condition is greatly decreased by cleansing of the teeth and dentures after use, yet the fact remains that this vicious type of design has been the means of needless sacrifice of a large percentage of teeth, which may be entirely avoided by a properly designed and executed *clasp*, kept *in contact with the enamel only*, which can be made with practically the same effort as the faulty type.

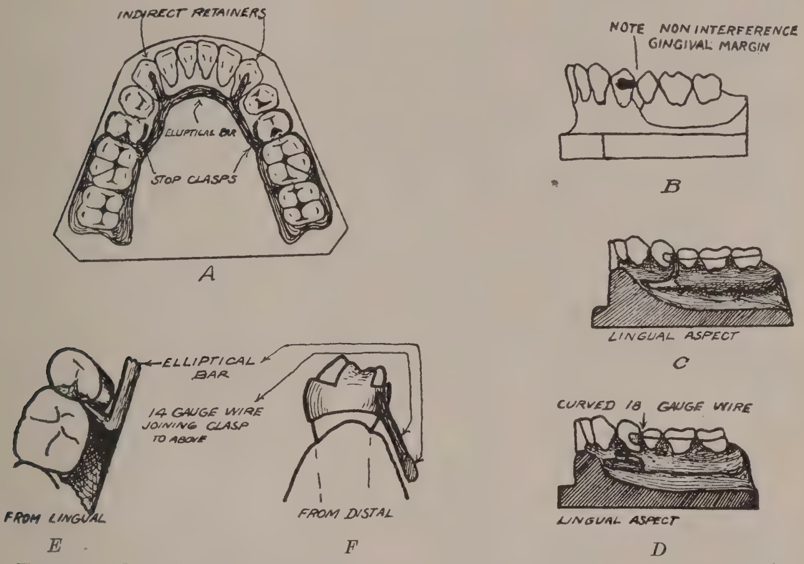


FIG. 319.—Detail of properly designed and constructed clasp (note clasp joined to base by rigid connector in such a manner as to allow the base to remain out of contact with gingiva); *A*, restoration for condition (note freedom of contact for denture at any point except clasps, which touch enamel only, and contact of indirect retainer); *B*, buccal view of same restoration (note lack of interference at the gingiva); *C*, lingual view of same restoration; *D*, sectional lingual view of a spring between the clasp and base; *E*, details of occlusal rest, connector, clasp, elliptic bar, etc., seen from occlusal side; *F*, the above seen from distal side.

Faulty Clasps without Occlusal Rests which "Settle" and Fail to Support Mastication.—As will be set forth in a subsequent section, an occlusal rest reaching from the clasp to the occlusal surface of the tooth is, in favorable cases, as considered in Fig. 321 and accompanying text, desirable by reason of more efficient support for mastication.

As a general proposition, Black has stated that the natural healthy teeth will carry from six to ten times the pressure that the mucosa will sustain, a conclusion based on comparison between a full natural and a full artificial denture. While these ratios can only approximately be applied to partial dentures, yet this explains an element of the faulty design in a large proportion of partial dentures in use and under construction in which no devices are used to engage the teeth to assist the mucosa in carrying the stress, where there are a sufficient number of teeth with sufficiently short edentulous spaces for this to be possible, as considered in Fig. 321 and accompanying text. Patients wearing such dentures are able to exert but a fraction of the masticating pressure, which diminishes both the quantity and quality of assimilation. In addition to this the occlusal rest effectively prevents the tendency on the part of the clasp to be depressed or "settled" between the free gingiva and the tooth. Such clasps, fitted at first close to the gingival margin, "settle" readily into the soft tissues, especially when attached to partial lowers with a limited saddle area. No greater or more destructive agency can be applied to the teeth of patients than such a clasp, which produces a combination of caries and a succession

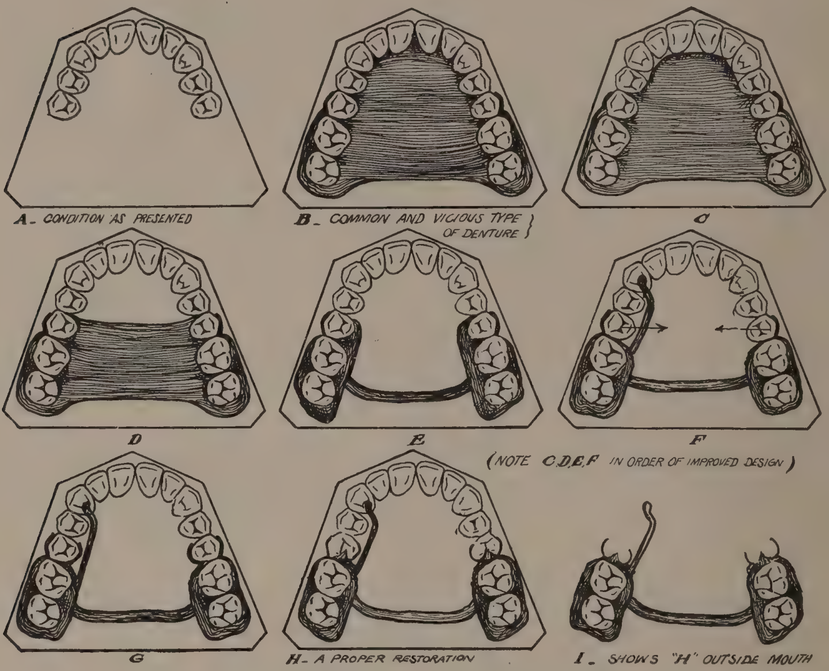
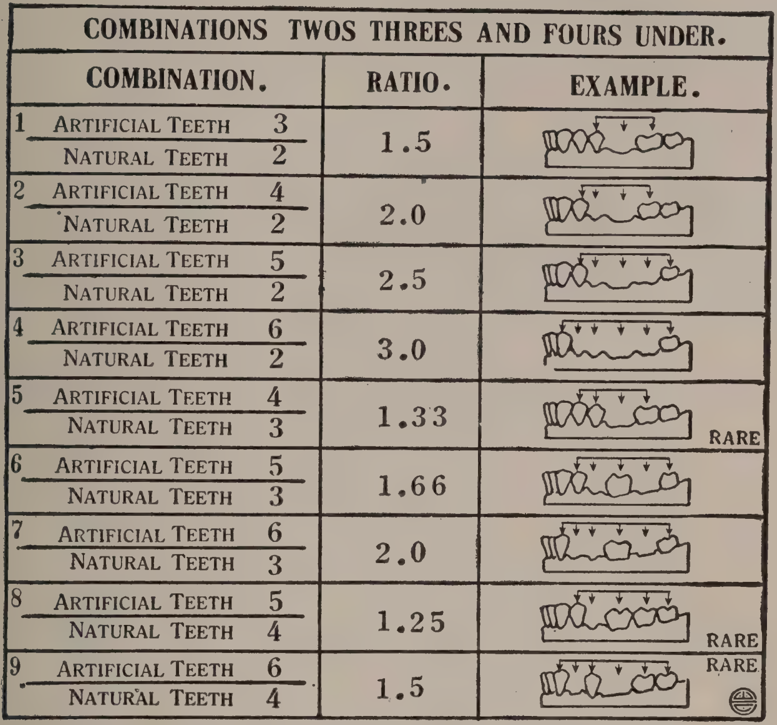

A_ CONDITION AS PRESENTED
B_ COMMON AND VICIOUS TYPE OF DENTURE
C
D
E
F
(NOTE C,D,E,F IN ORDER OF IMPROVED DESIGN)
G
H_ A PROPER RESTORATION
I_ SHOWS "H" OUTSIDE MOUTH

Fig. 320.—Series of designs showing, in reverse order of merit, anterior ten natural teeth in position. The problem is to supply molars. *A*, condition before restoration; *B*, worst design, interference of entire gingivæ by base, also with faulty clasp; *C*, better treatment of Case in *A*, as embrasures between anterior teeth are clear of the denture; *D*, better, anterior teeth entirely unaffected; lack of stability in denture at rear due to absence of indirect retainers and bicuspids engirdled by clasp and base at gingivæ; *E*, vault uncovered; eight anterior teeth clear; bicuspid engirdled as before; *F*, clasp fitted to buccal side only; danger of moving teeth lingually; indirect retainer fitted; *G*, *H*, a proper restoration; clasp with occlusal rest (three-arm clasp), indirect retainer; all parts out of contact except clasps and contact of indirect retainer; these in contact with enamel only; no gingival contact; *I*, restoration out of mouth (note that, if conditions warrant, a flexible connector may be used here), but which would result ordinarily in a denture not as efficient as one with a rigid connector.

of the various peridental diseases, which can only result in the sure and rapid destruction of the tooth from either, or from both.



COMBINATIONS TWOS THREES AND FOURS UNDER.		
COMBINATION.	RATIO.	EXAMPLE.
1 Artificial Teeth 3 Natural Teeth 2	1.5	
2 Artificial Teeth 4 Natural Teeth 2	2.0	
3 Artificial Teeth 5 Natural Teeth 2	2.5	
4 Artificial Teeth 6 Natural Teeth 2	3.0	
5 Artificial Teeth 4 Natural Teeth 3	1.33	RARE
6 Artificial Teeth 5 Natural Teeth 3	1.66	
7 Artificial Teeth 6 Natural Teeth 3	2.0	
8 Artificial Teeth 5 Natural Teeth 4	1.25	RARE
9 Artificial Teeth 6 Natural Teeth 4	1.5	RARE

Fig. 321.—An estimation of the capabilities of natural teeth at each end of an empty space in supporting loads, eliminating inhibited muscle traction and auxiliary mucosa support. The illustration shows various combinations of two, three and four teeth under the loads of three, four, five and six masticating surfaces.

The first space indicates three masticating surfaces over two roots. This is considered safe as $\frac{3 \text{ masticating surfaces}}{2 \text{ roots}} = \frac{3}{2} = 1.5$, which, it is estimated, roots can safely carry.

The second space we have $\frac{4 \text{ masticating surfaces}}{2 \text{ roots}} = \frac{4}{2} = 2.0$, which is estimated as safe.

The third space we have $\frac{5 \text{ masticating surfaces}}{2 \text{ roots}} = \frac{5}{2} = 2.5$, estimated as a possible overload, or on the border-line.

The remaining spaces work out in a similar manner, the fourth space being an estimated overload.

Faulty Saddles which come in Direct Contact with the Gingival Margin and with the Teeth Themselves.—Whether of gold or vulcanite, any part of any denture which rubs or presses on the gingival margin not only rides upon and irritates this margin, but also holds food in solid or dissolved form upon the surfaces of the teeth involved at which the least possible resistance to caries is offered. Such dentures have been in very extensive use by the dental profession, and have resulted in the loss of a large number of teeth. This may be avoided in the greater number of cases by the modifications in design.

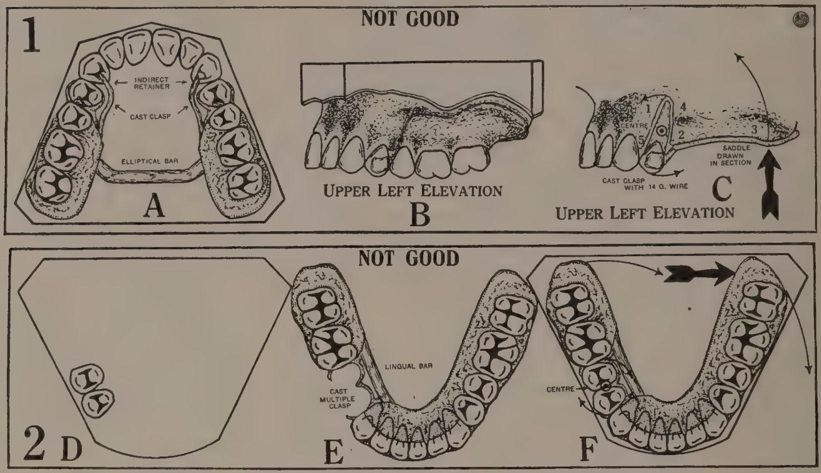


Fig. 322.—Illustrations of torque in both sagittal and horizontal planes. *1* indicates a restoration which places a torque upon the bicuspid teeth that becomes a leverage as the root is pressed against the alveolar process at *C2*, the process becoming in a sense the fulcrum. At the same time there is pressure at *C1* and negative pressure at *C4* and *C5*, as considered below. *2*, tightly and accurately cast clasps of width indicated, also a condition of soft mucosa under the saddle being presupposed (and, as may be seen, torque would be greatly minimized should the mucosa support be more firm). *A*, plan of restoration; *B*, elevation; *C*, indicating torque forces at work, from approximate center, as indicated.

In diagram *1C* the heavy arrow indicates the pressure of mastication and the saddle being driven against, and sinking into, the underlying mucosa. The saddle and clasp being continuous, and the tooth being firmly held, an actual rotation or torque takes place, the approximate center of which is indicated in the middle of the tooth, and the direction indicated by curved arrows. This torque causes compression areas at *1*, *2* and *3*, also stretching or tension areas at *4* and *5*. *2D*, *2E* and *2F* indicate a torque which may be followed by a leverage on a horizontal plane. *2D*, before treatment; *2E* the appliance (also faulty, in that the cast multiple clasp should be a wrought clasp) in some cases with a flexible connector; *2F*, indicating the torque with heavy arrow indicating force of lateral movement in masticating. Should the ridges be prominent and the mucosa dense, this torque is greatly minimized. The center of rotation or torque is indicated by the small circle at the contacts of the teeth; the curved arrows also indicate the direction of torque.

Mucosa Overload.—An overload of the mucosa will occur when saddles of too small area are placed upon it. Examples of this weight occur from a choice of a skeleton base rather than one covering the entire vault, as in Fig. 320, and also from a short saddle carrying two teeth without occlusal rests.

Pericememtum and Subjacent Bone, Overload.—Based upon clinical observation extended over many decades, it may be assumed that, among the posterior six teeth, the teeth at the end of an enclosed space (with natural teeth at both ends of the space) caused by two missing teeth will support without overload a bridge retaining these teeth, assuming that occlusion and other details of the replacement are up to standard. From this it is assumed, as noted in Fig. 321, that

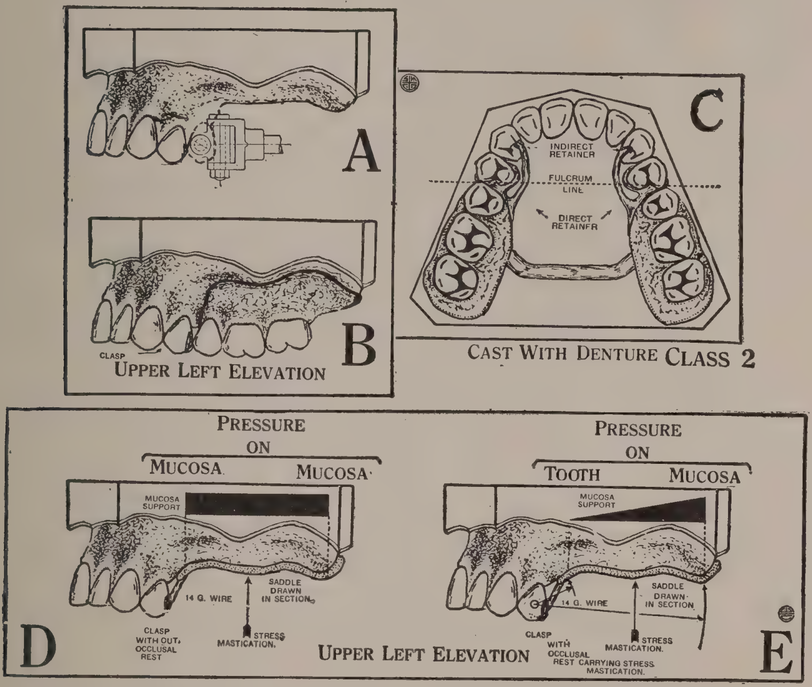


Fig. 323.—Overcoming torque on a space with a tooth or teeth at one end only, and the approximate distribution of the load with and without occlusal rests. *A*, diagrammatic representation of Hooke's universal joint, indicating something of this freedom of motion about the tooth, yet capable of delivering load to it, similar to a clasp with occlusal rests; *B*, *C*, plan and elevation of case chosen as illustrated; *D*, case with clasp and no occlusal rests, or with flexible connector; the black rectangle indicates absorption of whole load of the mucosa, without torque on bicuspids; *E*, case with clasp and occlusal rest; the black triangle indicates absorption of load—tooth absorbing load at mesial end of saddle, and tooth support decreasing and mucosa support increasing toward the end of the saddle, at which point it is entirely mucosa-borne. The clasp must be free to rotate about the tooth, which, as a rule, may be accomplished by having wrought clasps with flexible arms, and by keeping the body of the clasp above the guide line. See Surveying and Design of Clasps, p. 324. Note.—Rotation does not occur unless the direct retainers have occlusal rests or their equivalent.

spaces of one, two or more and, under favorable circumstances, three missing teeth may carry root supported restorations; meaning in partial denture service that occlusal rests of the most suitable type are indicated at each end of the partial denture restoring the teeth in this space.

Torque, Vertical and Horizontal.—In the case in Fig. 322, should the pericementum be compressed against the alveolar process to such an extent as to act as a fulcrum, torque is then followed by leverage. Hence in Fig. 322, *C*, should the torque proceed to such an extent that the pericementum at 2 is compressed and forms a fulcrum, a first class lever is set up, with *P* at the heavy arrow (masticating power or force), *F* at 2 and *W* compressing the pericementum at 1 and 2, with the reverse condition 4 and 5. Should, however, the compression of the pericementum and consequent fulcrum first occur at 1, a second class lever is established with *P* at the heavy arrow (masticating power or force), *F* at 1, and the resulting *W* at 2. The foregoing is an incomplete description of these destructive conditions as they operate more or less in all planes, while the above illustration is in a vertical plane only. The remedies for these conditions are: substitution of wrought clasps for cast clasps; interposition of flexible connectors (Fig. 309) or modification of clasps, so that they readily rotate upon the anchor teeth (Fig. 323).

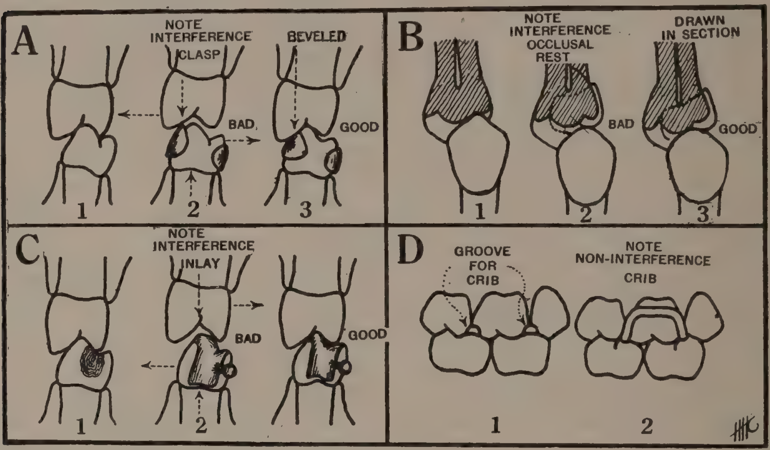


Fig. 324.—Interferences in the occlusal position. In the upper diagram at *A* an interfering clasp is shown: (1) before fitting; (2) fitted, but interfering; (3) after the interference is corrected. *B* and *C* show similar instances, except with an occlusal rest, and with an inlay for an interlocking attachment. *D* indicates a shallow groove at the expense of the marginal ridges and the opposing cusps for a crib, avoiding a similar interference. The rule is that the remaining teeth should articulate the same with or without the appliance.

Inclined Planes.—Any part which delivers a load against the sloping surfaces of natural teeth will react against these teeth as an inclined plane, driving them against the alveolar border, somewhat similar to the condition shown in Fig. 322. Illustrations of faulty occlusal rests and other inclined planes are shown in Fig. 324. The most prolific source, however, is faulty articulation (see chapter on Articulation, p. 222).

Intermaxillary Balance.—Another important phase of the loading problem may be noted by a study of Fig. 325, in which various balanced and unbalanced intermaxillary combinations are shown. For example, in this Fig. 325, combination No. 1, showing upper and lower, right and left posterior teeth in contact, is an example of intermaxillary balance, while combination 7 showing upper and lower right posterior teeth only in contact, is an example of intermaxillary unbalance.

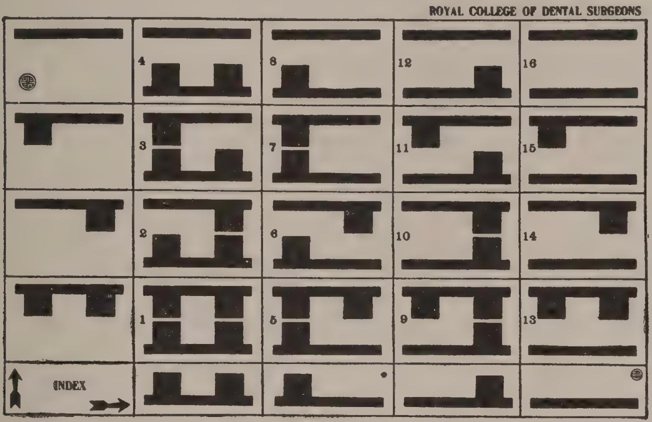


FIG. 325.—Mandible balance. The above diagram shows diagrammatically the various combinations of four groups of teeth present and missing, omitting the upper and lower anteriors. Each block on the horizontal lines, which represent the upper and lower jaws, represents the upper and lower, right and left groups of the posterior six teeth. Nos. *1*, *4*, *13*, and *16* with restorations would show mandibular balance during function; Nos, *2*, *3*, *5*, *6* and *11* show a lack of balance which may be cared for in denture service; Nos. *7* and *10* show a lack of balance somewhat difficult to care for under certain circumstances.

In all cases of intermaxillary unbalance, every precaution, such as maximum saddle area, root support when possible, and systematic inspection, with rebasing where necessary, is indicated. Otherwise there is danger in such an extreme case, with all teeth removed save the bicuspids or molars on, say, the right side (as in Fig. 325, space No. 7), of the entire mandible moving to the left, with accompanying disturbance of the glenoid fossa.

THE PRACTICE OF PARTIAL DENTAL SERVICE.

The Practice of Partial Denture Service.—Having acquired and mentally classified the principles of the science of partial denture service, these may be used as a guide to correct procedure in the practice of partial denture service. Practice is made up of five stages: Preliminary examination, design, construction, installation and maintenance.

1. *Preliminary Examination.*—The preliminary examination is made to gather all of the facts which bear upon the subsequent phases of the service and may include study casts, radiograms and other data. The choice of the appliance is made at this stage, namely, full denture, partial denture or crown or bridgework.

2. *Design.*—A mental or graphic picture must precede all engineering construction. In partial denture design the theoretical principles are made use of as needed in the development of design. The main item of practical value at this stage is that of a *mental and graphic technic which follows for the development of any design for any combination of teeth* in four simple stages[1] on paper.

3. *Construction.*—Having developed mentally or on paper the correct design, the next step is that of actual construction. Accuracy, lightness, small bulk as possible, rapidity, ease, and low cost are of primary importance. In the opinion of the writer, much research and invention are needed here.

4. *Installation.*—Many fine pieces of well-designed and constructed prosthetic work are failures for the sole reason of lack of care in installation. Hence the importance of this step.

5. *Maintenance and Repair.*—Many pieces of well-designed, constructed and installed prosthetic work become failures for the sole reason of improper maintenance and prompt necessary repairs. The patient here divides the responsibility with the dentist. Hence, also, the importance of this step.

A summary of some of the outstanding points in the Practice of Partial Denture Service will be found below (Chart 8.)

Examination, Records, etc.—The first procedure, following the initial appointment, is a careful surface examination of the mouth and all the remaining teeth, procuring the history and radiograms of all doubtful teeth or roots involved. As is well known among the dental and medical profession, this often reveals septic foci at the apices of unsuspected teeth. In the event of doubtful success of accepted methods of root-canal, peridental, or periapical treatment, as a rule, extraction should follow, for it would seem that no precept of modern dentistry should be more carefully safeguarded than the protection of the patient's present and future health from dental lesions. Should a tooth or teeth, suspected of being the cause of systemic infection, or even suspected of being septic without symptoms of general infection, for special reasons be allowed to remain in the mouth of the patient, they should never be used either in the support or retention of the denture, because of the obvious necessity of a radical change in design should these become lost. Designs should always provide for the possibility of future extractions of a doubtful tooth or root, and future inexpensive and simple replacement upon the framework of the denture.

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[1] It may be noted that it is not always necessary to develop the simple designs on paper.

PRACTICE OF PARTIAL DENTURE SERVICE (CHOICE AND EXECUTION OF).

(Preferably in collaboration with the Physician, Surgeon, Radiographer, Diagnostician, Periodontist, Orthodontist, Exodontist, or others if necessary.)

1. *Preliminary examination*
    1. General examination (if required, by physician)
    2. Dental examination
        1. An examination, with radiograms, study casts, photographs, and any records necessary.
        2. Diagnosis and cure of disease.
        3. Realignment of remaining natural teeth for the various positions in occlusion.
        4. A study of the type of mentality of the patient.
        5. The choice of the appliance, full or partial dentures, crown or bridgework, or any, all, or none of these.
2. *Design*
    1. Saddles (allocation of load to mucosa)
        1. Skeleton.
        2. Non-skeleton.
        3. Continuous.
        4. Covering entire upper vault.
    2. Parts connecting saddles
        1. Upper between the rugæ.
        2. Upper between the molars.
        3. Lower at line of peripheral seal.
    3. Direct and indirect retention and connectors
        1. Class 1, D and I.R. × (2D.[1]).
        2. Class 2, D. and I.R. + (2D.).
        3. Class 3, D.R. ⊓ (2D.).
        4. Class 4, D.R. △ (3+D.).
    4. Occlusal rests (allocation of load to teeth and their pericementum)
        1. Recessed.
        2. Surface, including partial, full and multiple-occlusal rests and pads and rests for occlusal cone.
3. *Construction*
    1. Direct retainers and occlusal rests completed, checked for interference, and in mouth.
    2. Impression
        1. For rod supported dentures (Roach or Rudd methods).
        2. For mucosa supported dentures (primo-secondary method).
        3. For combination supported dentures (primo-secondary method).
    3. Cast
        1. Stone for casting-assembly method, or for vulcanite.
        2. Investment material for all-cast method.
    4. Construction of the base
        1. For metal.
        2. For vulcanite or its equivalent.
    5. Inspection in mouth (spot-grinding if necessary)
        1. Vulcanite with temporary wax base.
        2. Metal, as finished.
    6. Anterior teeth—applied esthetics.
    7. Posterior teeth—articulation and occlusion.
    8. Inspection in mouth, teeth in wax mount.
    9. Finishing.
4. *Insertion or installation*
    1. Before piece snaps "home." Carbon paper and spot-grinding . . . . As necessary.
    2. After piece snaps "home" (final and minute allocation of load) . . Carbon paper and spot-grinding. As necessary.
    3. Teach patient and have patient practise insertion and removal before leaving.
    4. Subsequent adjustment and rebasing at subsequent sittings, until load is properly distributed.
5. *Maintenance* (the patient here takes part)
    1. General oral health—diet, exercise; elimination; immunity, etc.
    2. Saliva flush and cleansing.
    3. Removal night, if this is desirable.
    4. Notification.
    5. Repairs (prompt):
        - (*a*) fractures and simple replacements.
        - (*b*) additions for teeth lost.
        - (*c*) other repairs.
    6. Literature for patients covering above.

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[1] D here means "direct retainers."

CHART 8.—Diagram of the stages in the practice of partial denture service.

Study Casts and Sketches.—These are as necessary in the design of a partial denture (outside of the extremely simple forms) to the dentist as the blueprints of the architect or the machine builder. In partial denture restoration, in most instances, and especially in cases in which it is necessary to "open the bite," or to produce permanently a greater separation of the teeth, a careful scrutiny of the mouth fails to reveal proper proportions and relations, while from study casts made from modeling compound impressions, all proportions as well as lingual relations are more clearly visible. As an aid to the use of the study cast, and as a preventive for the needless marking of the study model with pen or pencil, the writer has great satisfaction in the use of rubber stamps (Fig. 326). With these, tentative sketches may be readily made and used with or without a study cast, as the complexity of the problem may indicate.

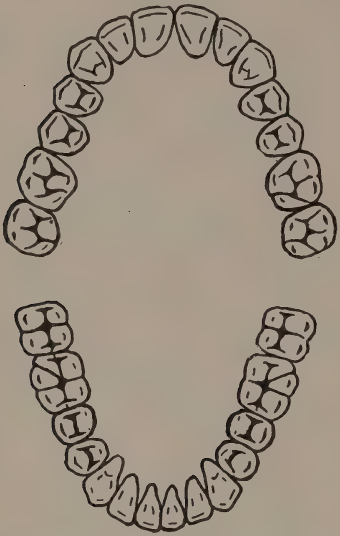

Fig. 326.—Imprint of rubber stamps used by the writer. Drawings of teeth taken from Prothero's Prosthetic Dentistry. From these cuts a zinc etching can be readily made by any photo-engraver, from which any number of printed pads or rubber stamps may be made. Third molars may be sketched in, if necessary, for individual cases.

First Steps in Evolving the Design.—As previously pointed out, immediately following the examination, note is made of the teeth which are to remain and those which are to be or have been extracted. In evolving the design for partial dentures, the most suitable manner in noting these condemned teeth upon the pad upon which the set of teeth has been previously imprinted, is to enclose them in a line which represents the outline of the saddle which will carry the future replacements. In addition to this, fillings or inlays which may, or may not, be used in the restoration, may be outlined and crowns or bridges also indicated. Thus the mind is greatly aided in evolving the design, of which the next step is to sketch in the constructional parts which are to join these saddles with the framework of the restoration itself.

Colors are very useful, not only for making a more vivid picture for the partial denture designer, but also for specifications, the colors suggested being black for the outline, red for vulcanite or its equivalent, and orange for gold. A sketch of the proposed appliance shown to an inquiring patient in colors creates a more favorable attitude toward the proposed treatment than one in black and white, or no sketch at all. Both ordinary cedar and also pencils of the "Eversharp" type may be had with both the pencil bodies and the leads in these colors. For permanent records, such as would be made upon such a card as shown in Figs. 330 or 331, the following inks are recommended, used conveniently with three pens, having bodies of the corresponding colors: Higgins' India ink (black) and Higgins' Orange and Crimson ink.

Designs for Cases Requiring Anterior Extraction with Minimum Delay in Restoration.—The examination of radiograms and history of the individual teeth having been made and the decision involving the extraction or retention of the individual teeth crystallized from these, the extraction of those teeth which are condemned, and which lie posterior to the cuspids, then follows. Any anterior teeth which require extraction may be removed subsequent to the completion of the framework which carries them, which renders it unnecessary for the patient to be conspicuous through the extraction for a period longer than a half day. The manner in which modern partial denture construction lends itself to this procedure may be seen in Fig. 328.

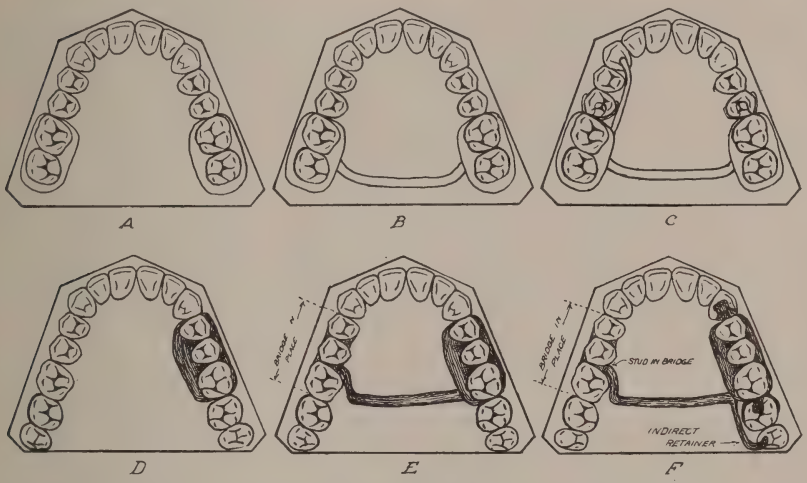

FIG. 327.—Steps in evolving a design. *A*, first step in evolving a simple design, as already referred to, sketching saddle outlines around teeth either removed or to be removed; *B*, second step, joining these saddles by constructional parts (there are no operative details in this case); *C*, third and fourth steps, direct and indirect retainers sketched, and occlusal rests completing this design (see Indirect Retention); *D*, saddle outline sketched around teeth in another restoration, third molars also sketched in, these teeth being present in the mouth; *E*, additional details also sketched in (inlay and bridge); *F*, direct and indirect retainers with occlusal rest sketched in (stud in bridge and three-arm clasp with occlusal rest recessed in inlay in cuspid).

Saddle Design. Allocation of Load to Mucosa.—In the design of saddles, the mucosa is given its share of the load. The softer the mucosa, the larger should be the saddle. A slightly intermittent pressure is more favorable, and a steady pressure in excess compresses the circulation, causes a so-called "strangulation" with resorption similar to too great peripheral valve seal on full dentures.

In outline the saddles should be kept away from the gingival margin. With regard to saddle area, Dr. Chayes' statement that "saddle area must equal combined pericemental areas of teeth missing and supplied" probably approaches the closest so far to the solution.[1]

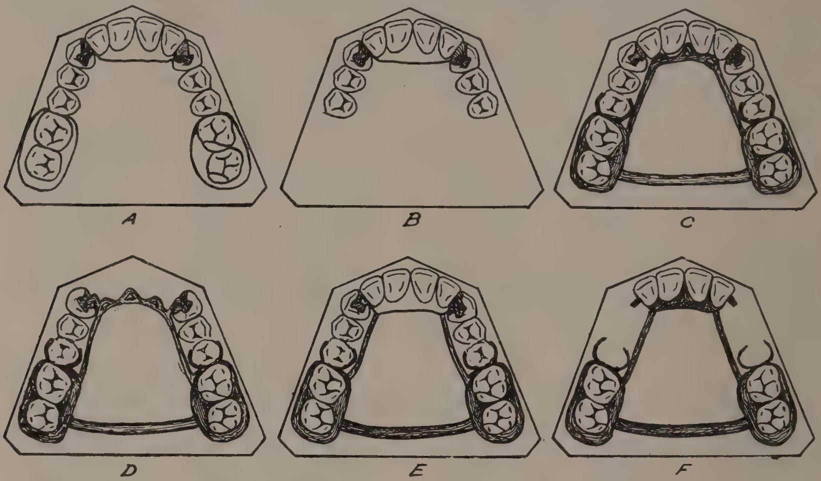

Fig. 328.—An instance in which anterior extraction is delayed until the framework carrying the anterior teeth is finished, allowing almost immediate replacement of these teeth. The above represents a restoration made by the Canadian Army Dental Corps. *A*, diagram of case; teeth enclosed in lines to be extracted; *B*, diagram of mouth after first extraction, anteriors yet untouched; *C*, diagram of restoration as completed immediately prior to second extraction. Two-arm clasps on second bicuspids, flattened clasp metal bar fitted and carried forward bearing loops of clasp metal of 18-gauge fitted in the embrasures; saddles, at this time, of wax only; inlays in cuspids prepared, made and fitted *in situ*, with slots for the 14-gauge occlusal rests; the four anterior teeth are now extracted; *D*, skeleton work with inlays fitted but not cemented in place, ready for second impression; sprues left on inlays to facilitate withdrawal in plaster; impression in plaster now made, removing inlays and skeleton; upon the subsequent cast occlusal rests are made to fit cuspid inlays, joined with solder to the framework; wax trial plate now built out over the anterior teeth and molars, the bite taken and antagonizing cast already made (fusible metal from plaster impression); teeth now added by vulcanization; *E*, restoration in position one-half day after second extraction; *F*, restoration outside of the mouth; following natural resorption, plaster may be added to the mucosa side of these saddles and mucosa contact restored as needed.

Below follow steps in saddle design:

Upper and Lower.—1. Buccal periphery, posterior, to be carried to peripheral valve seal.

2. Buccal and labial periphery, anterior, as above, unless no artificial gum is desired.

3. One to two millimeters space about teeth to avoid capillarity.

4. Lingual periphery as determined by area of mucosa support desired in the next step.

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[1] Items of Interest, November, 1915.

Parts Connecting Saddles.—These, when required, are almost always located to the lingual of the teeth, occasionally buccal and labial, and may be developed as below.

Upper and Lower.—1. If alternate space and tooth or similar, use continuous construction (Plate I, Square 14).

2. If alternate space and group of teeth or similar, use skeleton construction.

Upper.—3. If parts required to cross anterior, flat or semiround, cast or wrought, these are placed in a suitable depression between rugæ. If this is not possible, flat wide piece.

4. If parts required to cross posterior, between first and second molar, cast or wrought, flat or semiround, and if mucosa or combination support, compensated for differences between hard and soft areas.

5. Choice between parts crossing the anterior, posterior, or both; this depending on strength of appliance required, range, available space, occupation and choice of patient, and other factors.

If Soft Mucosa, Upper.—6. All saddles should be extended to cover mucosa over entire vault.

Lower.—7. All parts connecting lower saddles (lingual bar) low as muscle attachment will permit, and 1 or 2 mm. lingual from soft tissues (unless the denture is entirely root-supported).

All-vulcanite construction (including the newer phenol-base materials) is desirable only, as a rule, when costs must be reduced to an extreme minimum; or in unusually large restorations such as following maxillary resection, accidents or surgery involving large losses of teeth, or under similar conditions.

Position and Choice, Retaining Devices (at which Step the Case Becomes Classified).—Should clasps be chosen, those of smallest dimensions consistent with efficiency to reduce capillarity are preferred, if possible two only in number (Classes 1, 2, 3). Cast-clasps should not be used in locations causing torques. A suggested detail for the positioning and choice of retainers follows:

1. With small straight-edge at hand, choose paired (Classes 1, 2, 3) or triplet (Class 4) in the following steps:

(*a*) Lay straight-edge across opposite pairs of natural teeth adjacent to edentulous spaces, so as to allow the straight-edge to pass across the center of area of figures outlined in steps 1 and 2 (usually omitting central and lateral incisors and third molars). Classes 1 and 2.

This being inexpedient:

(*b*) Lay straight-edge across opposite pairs of natural teeth adjacent to edentulous spaces, so as to allow the straight-edge to pass across the center of area of the entire arch (Classes 1 and 2). Add indirect retainers if desired usually omitting the use of central and lateral incisors upper and lower. This brings the fulcrum line approximately in the center of area of the piece, producing balance.

(*c*) Lay straight-edge on pairs of teeth in line on one side of figure developed in steps 1 and 2, which may afford retention, with or without auxiliary adhesion (Class 3).

This being inexpedient:

(*d*) Lay straight-edge on three teeth (or, if necessary, four teeth) in a triangular or quadrilateral relationship. (Class 4.)

2. Select from (1) the most favorable paired group, or if not possible, (2) the triplet or quadruplicate group of teeth most suitable for clasps.

(*a*) Teeth with decided opposing convexities (mesio-distal, bucco-lingual, or line-angle).

(*b*) Teeth of good pericemental and enamel condition.

(*c*) Teeth with freedom from caries, erosion, abrasion, large fillings, inlays, etc.

(*d*) Teeth remote as possible from the anterior mouth.

(*e*) Teeth with other indications for clasps not mentioned above.

3. This being in whole or in part impossible, choose (as above) compound retainers, especially in teeth, either requiring, or with readily replaceable large inlays, crowns or similar restorations.

(*a*) Non-precision, if saddle supported at one end only.

(*b*) Precision if grade of work admits.

4. In Classes 1 and 2 add indirect retainers, if necessary (contact or carrying stress of mastication) upon suitable teeth, omitting upper and lower central and lateral incisors; these indirect retainers to be directly opposite unretained portions of saddles.

Connectors.—Connectors may be chosen and placed. These may be of the rigid 14-gauge type placed in the embrasure except in cases in which disproportion exists between the movements of the saddle and anchor tooth, or for similar reasons (see p. 376). In such cases non-rigid connectors may be used.

FACTOR CHART.

For the purpose of assisting in the determination of support (steps Nos. 1, 2 and 4) in design, Chart 3.

1. *Some factors indicating mucosa support:*

Larger saddle areas with stress of mastication carried primarily by saddles and subjacent mucosa, and without occlusal rests, are indicated in proportion to:

- (*a*) Larger distances on each side of remaining teeth.
- (*b*) Smaller amount of pericementum supporting these teeth.
- (*c*) Less favorable condition of pericementum of teeth available, or not available for support.
- (*d*) Less firm condition of the mucosa.
- (*e*) Pressure from the antagonizing teeth above the average.

2. *Some factors indicating root support:*

Smaller saddles with stress of mastication carried primarily by the teeth and their pericementum; and with occlusal rests, are indicated in proportion to:

- (*a*) Smaller distance between the remaining teeth.
- (*b*) Large amount of pericementum supporting these teeth.
- (*c*) More favorable condition of pericementum of teeth available for support.
- (*d*) More firm condition of the mucosa.
- (*e*) Pressure from antagonizing teeth below the average.

3. *Some factors indicating combination support:*

With stress of mastication divided between roots and mucosa, with saddles of medium area and with occlusal rests.

- (*a*) Practically the remainder.

CHART 9.—Factor sheet. From the above, in proportion to the factors present in the proposed restoration, is the type of support developed: (*a*) root; (*b*) mucosa; (*c*) combination support of both root and mucosa.

Position and Choice of Occlusal Rests.—(Allocation of load to the teeth and their supporting structures. Load *must be applied to teeth in a direction coincident with their long axes only.*)

At this stage the occlusal rests (if their use is thought desirable) may be drawn in, which allocates the load to the teeth. This is also an unexplored field, and in the judgment of the writer is best taught by factors indicating root support, governed by the general principles that saddles resting on soft mucosa tend to throw bulk of the stress on the teeth, and also that teeth of diminished or diseased pericementum should be given this duty. Some writers on this subject condemn this principle, thus eliminating the allocation of the load for the tissues designed by Nature for the purpose—the teeth and their supporting structures—in which the writer is unable to wholly concur.

In many cases the sequelæ following non-occlusion may be prevented with large occlusal rests in cases immune to caries. Capillarity in these may be minimized by keeping the gold out of contact with the deep sulci. Reference to this is made in Figs. 313 and 314.

A sequence for the development of these follows:

1. Determine support of piece; see Factor Chart, Chart 9.
2. Sketching in occlusal rests.

(*a*) If mucosa support, no occlusal rest.

(*b*) If root support entirely (removable bridges), occlusal rests, with or without saddles.

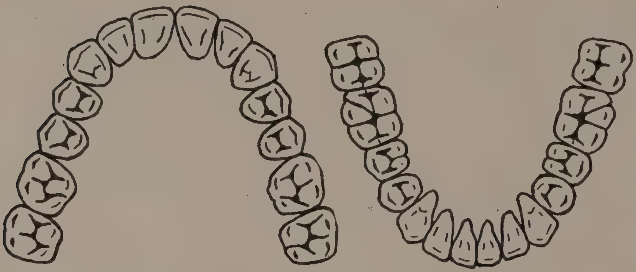
(*c*) If mucosa and root support with *ample space* for occlusal rest, quarter, half, full, or multiple occlusal pads as required to close space.

(*d*) If both mucosa and root support with *small space* for occlusal rest, buccal or lingual entry surface occlusal rest; mesio-distal, bucco-lingual, or linguo-incisal, rigid loops; recessed occlusal rests. Remove small amount of enamel from marginal ridges of upper and lower teeth involved, if absolutely unavoidable, and without approaching the dentin.

Construction.—Maintenance of accuracy is the chief difficulty in construction and much research in stresses and strains in bent and cast metal to avoid distortion is necessary. A shrunken casting or distorted framework exerts a permanent stress on anchor teeth which must result in ruin. Interference in articulation may be checked by intelligent use of adjustable articulators. Escapes provided on occlusal surface tend to reduce the overload. In Chart 8, a series of items in construction may be noted, details of which would necessitate an essay of considerable length. It is therefore possible only to touch briefly upon certain outstanding phases of construction, because, in the five stages in partial denture service, construction has heretofore been foremost in the literature or at professional conferences.

Impressions and Trays.—Inasmuch as this title forms the subject for a chapter in this text, the writer will not make reference thereto except to refer to the necessity of having any clasps and inlays (with uncut

PATIENT	REFERENCE	APPROXIMATE COST
HOUSE ADDRESS TELEPHONE	A/C TO	
BUSINESS ADDRESS TELEPHONE	DETAILS OF PAYMENT	NOTES



OTHER OPERATORS DOCTORS,—

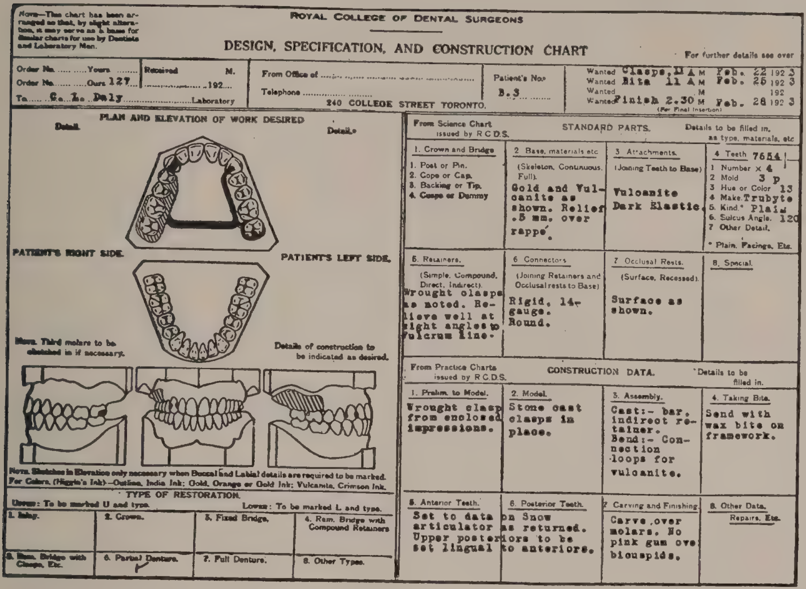
FIG. 329.—(*a*) Face side of card (prosthesis only). Card recommended in practice confined to prosthetics. Size 4 x 6 inches.

DATE.	ITEMS.	Sitting.	Time.	DEBIT.	CREDIT.	DATE.	ITEMS.	Sitting.	Time.	DEBIT.	CREDIT.
							FORWARD				
	TOTAL										

FIG. 330.—(*b*) Reverse side of card (prosthesis only).

sprue wires) crowns, etc., *in situ*, in the mouth and uncemented for withdrawal.

For some time past it has been felt that there has been room for improvement in methods of partial denture impressions under the following principal heads:



NOTE—This chart has been arranged so that, by slight alteration, it may serve as a base for similar charts for use by Dentists and Laboratory Men.

ROYAL COLLEGE OF DENTAL SURGEONS

DESIGN, SPECIFICATION, AND CONSTRUCTION CHART

For further details see over

Order No. ....Yours ....
Order No. ....Ours 127...
To...... C. L. Daly ....Laboratory

Received M.
.... 192....

From Office of ....
Telephone ....
240 COLLEGE STREET TORONTO.

Patient's No. B.3 ....

Wanted Clasps, 11 A M Feb. 22 1923
Wanted Bite 11 A M Feb. 25 1923
Wanted M 192
Wanted Finish 2.30 M Feb. 28 1923
(For Final Insertion)

PLAN AND ELEVATION OF WORK DESIRED

Detail. Detail.

PATIENT'S RIGHT SIDE. PATIENT'S LEFT SIDE.

NOTE. Third molars to be sketched in if necessary.

Details of construction to be indicated as desired.

NOTE. Sketches in Elevation only necessary when Buccal and Labial details are required to be marked.
For Colors. (Higgin's Ink)—Outline, India Ink; Gold, Orange or Gold Ink; Vulcanite, Crimson Ink.

TYPE OF RESTORATION.

UPPER: To be marked U and type. LOWER: To be marked L and type.

1. Inlay.	2. Crown.	3. Fixed Bridge.	4. Rem. Bridge with Compound Retainers
5. Rem. Bridge with Clasps, Etc.	6. Partial Denture. ✓	7. Full Denture.	8. Other Types.

From Science Chart issued by R.C.D.S. STANDARD PARTS. Details to be filled in, as type, materials, etc.

1. Crown and Bridge 1. Post or Pin. 2. Cope or Cap. 3. Backing or Tip. 4. Cusps or Dummy	2. Base, materials etc (Skeleton, Continuous, Full). Gold and Vulcanite as shown. Relief .5 mm. over rappé.	3. Attachments. (Joining Teeth to Base) Vulcanite Dark Elastic.	4. Teeth 7654 1 Number x 4 2 Mold 3 p 3 Hue or Color 13 4 Make. Trubyte 5. Kind.* Plain 6. Sulcus Angle. 120 7 Other Detail. * Plain, Facings, Etc.
5. Retainers. (Simple, Compound, Direct, Indirect). Wrought clasps as noted. Relieve well at right angles to fulcrum line.	6. Connectors (Joining Retainers and Occlusal rests to Base) Rigid, 14-gauge. Round.	7. Occlusal Rests. (Surface, Recessed). Surface as shown.	8. Special.

From Practice Charts issued by R.C.D.S. CONSTRUCTION DATA. Details to be filled in.

1. Prelim. to Model. Wrought clasp from enclosed impressions.	2. Model. Stone cast clasps in place.	3. Assembly. Cast:- bar, indirect retainer. Bend:- Connection loops for vulcanite.	4. Taking Bite. Send with wax bite on framework.
5. Anterior Teeth. Set to data on Snow articulator as returned. Upper posteriors to be set lingual to anteriors.	6. Posterior Teeth.	7. Carving and Finishing. Carve over molars. No pink gum over bicuspids.	8. Other Data. Repairs, Etc.

FIG. 331.—Specification chart, with details supplied by Dr. G. W. Graecen. Should the dentist collaborate with a laboratory associate who lives at a distance, a specification chart is valuable. The size of this chart is letter size, 8½ x 11 inches.

For Impressions for All Partial Dentures:

(*a*) Greater certainty that all parts are covered by the impression.

(*b*) Greater ease and certainty of manipulation (resulting automatically in higher standards of partial denture impressions).

(*c*) Accurate reproduction of complex undercuts (essential in surveying for clasp design, p. 325).

(*d*) Greater comfort to the patient, with less bulk of material and shorter intervals during which the material is in the mouth.

And Also for Impressions for Mucosa or Combination Supported Partial Dentures:

(*e*) Greatest available base area covered, and taken under light biting stress, or other stress as desired.

(*f*) Possibility of muscle-trimming and post-damming as in full denture service.

In a progress report of some studies which has appeared in the literature[1] dealing with impressions for mucosa and combination supported partial dentures alone, a primo-secondary method is proposed, which is planned to approach full denture impression methods as nearly as possible. Here follows an outline of the procedure.[1]

---

[1] Dental Cosmos, September, 1926, December, 1927 and January and March, 1928.

A Proposed Impression (Primo-secondary) Technic for Mucosa and for Tooth-mucosa Supported Partial Dentures.

Step 1. *The Dentist* will select stock tray, take an approximate impression, have study cast made and complete the design of the denture. If mucosa or tooth-mucosa support is chosen—

Step 2. *The Assistant* will

(*a*) Outline a tray on study cast as for a full denture, with a pencil, but with the undercuts (dental or alveolar) exposed.

(*b*) Make wax pattern and mold it in calcar; then cast the tray in commercial tin (442° F.).

Step 3. *The Dentist and the Assistant* will

(*a*) Make a thin primary impression (also exposing all undercuts) with the tin tray, using stick compound.

(*b*) While the primary impression is held in the mouth under a light biting stress, make the secondary impression of the undercuts in the exposed teeth and alveolar borders in plaster (using small trays or a plaster syringe with or without vanes) or modeling compound sections, keeping up the stress until the secondary impressions are hard; then, releasing this pressure.

(*c*) Remove the secondary impression by either lifting out vane or cutting the plaster; or, if in compound, by removing the sections.

Step 4. *The Assistant* will re-assemble and box the impression and make the casts, using an all-plaster or stone construction, or amalgam or low-fusing metal for the teeth, as desired by the dentist. Should an all-metal cast be desired, the primary impression in Step 3 will be of plaster.

Note.—For the reason of unusual size in mouths with or without teeth, or for any other reason, the wax pattern for the tray in Steps 2 and 3 may be made directly in the mouth without a study cast, from which the tray is then made.

Fig. 332 will indicate that the primo-secondary method consists in (*a*) taking a primary impression of the mouth, preferably in modeling compound, with all the undercuts (dental or alveolar) uncovered by this impression. Having finished this primary impression, it is then returned to the mouth, and while there, (*b*) the secondary impression, or impressions, of the undercuts not included in the primary impression are then taken, preferably in plaster.

A special cast tray, made by the assistant, using commercial tin cast in molding sand, is recommended. The steps are outlined in Fig. 333.

---

[1] Oral Health, December, 1927.

A study of this report may suggest to the reader that, while such a plan for impression-taking may consume more time, yet, as has been learned from the change from full denture impression technic from a single incorrect impression, taking only a few moments, to the present-day corrected and tested impression, taking the best part of an hour, that perhaps the solution of the present partial denture impression problem, and indeed the accompanying problem of avoiding the frequent rebasing at present necessary, may lie in this direction.

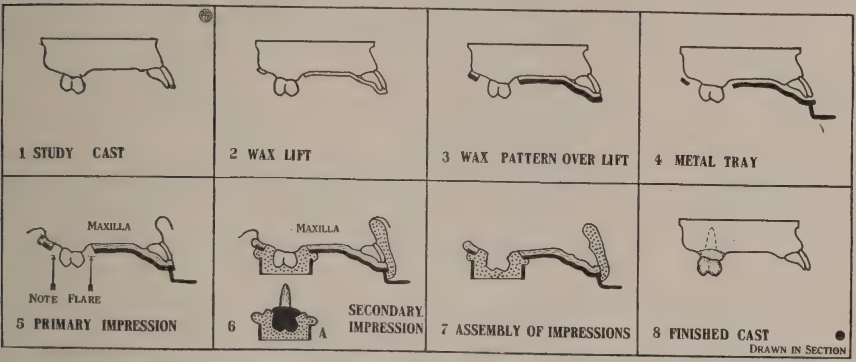


Fig. 332.—The primary-secondary method for cases for which mucosa support is planned in the partial denture, with the various stages shown in right elevation.

1. Study cast in plaster from an approximate modeling compound impression.
2. Cover the outline of the proposed tray with one or more thicknesses of base-plate wax to allow room in the tray for a proper amount of impression material. This base-plate wax is hereafter referred to as a *lift*.
3. Over this lift the wax pattern for the special tray is formed, without stretching.
4. A tin tray with a handle is cast in molding sand (calcar), with perforations for the remaining teeth. This casting can be done by an assistant in about ten minutes.
5. A modeling compound primary impression is taken, muscle-trimmed and post-dammed as required, and flared around the perforations.
6. The primary impression is finished and held in place by adhesion while the secondary impression in plaster is taken. Should a metal tooth or teeth be desired, it may be made here, as in 6*A*.
7. The *primary* and *secondary* impressions are removed from the mouth and assembled, ready to pour.
8. Finished cast, stone, with (as shown) or without a metal tooth.

Cast and Atagonizing Cast.—The various "stones" now on the market as substitutes for plaster are advantageous in that they make a cast harder than plaster. The materials should be handled according to instructions and worked carefully into the recesses in the impression made by the teeth. An eccentric stone on the lathe, operating on an impression boxed with "air-chamber metal," greatly assists in the packing process. For antagonizing casts in which correctly made full dentures, or dentures and natural teeth, or natural teeth alone are represented, nothing is better than a plaster impression half way down the necks of the teeth, into which may be poured fusible metal almost before the plaster is set, in accordance with the method shown to the writer by Dr. R. Gordon McLean, of Toronto. In articulating, the interfering points of porcelain blacken from the fusible metal acting in the same manner as carbon paper—a great convenience (Figs. 334 to 339).

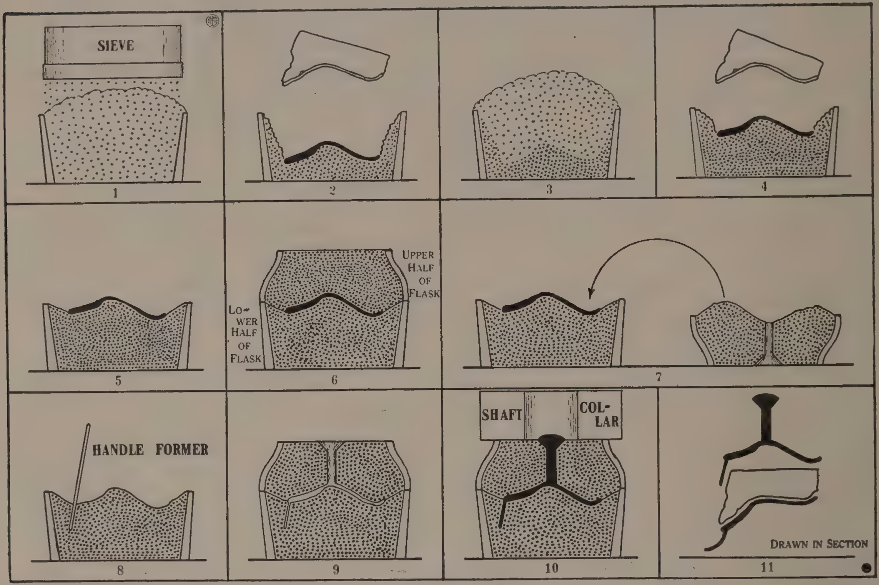


Fig. 333.—Molding and casting the special tray. The Bailey molding flask is used, of which the part with the curved profile will be called the upper half and that with the straight profile the lower half, as indicated in Square 6 above. Calcar, a molding compound suggested by Dr. Gritman for dental purposes, is proposed as an admirable molding sand in this work.

1. Sifting the sand with a 10-mesh sieve into the lower half of the flask.
2. The study cast with the wax lift and pattern, all dry and well dusted with French chalk, are pressed into the lower half of the flask with sufficient force for the sand to adhere firmly, and also, as far as possible, so that the edge of the pattern is equidistant from the edge of the flask. With the finger, or with the end of the brush handle the sand is well packed around the edge of the cast, and the cast, lift and pattern are removed. The picture shows the cast and the lift removed, but the pattern yet to be removed. Note the increased density of the sand.
3. The pattern is now removed and additional sand is sifted in.
4. The process in square 2 is repeated until—
5. The edges of the wax pattern are approximately level with the lower half of the flask, at which time the sand is finally compressed, leveled and smoothed with the thumb and finger, and the whole is well dusted with French chalk, the separating or "parting" medium.
6. The upper half of the flask is then fitted on; sand is sifted and packed in, and the top is leveled with the scraper.
7. The flask is then inverted and the *lower* half is lifted off the upper (because the sand is less liable to fall out of the lower than out of the upper, when inverted). Remove the wax pattern with a ½-inch cork borer; a sprue is made in the sand in the upper half of the flask, which in its upper part is given a funnel shape for the reception of the metal by rotating the heart end of the "Heart and Spoon" molder's tool in it from below.
8. With the handle former, a depression is made on the *lingual* side of the mold at the position in the mold at which the handle is desired. For a narrow handle the ¼-inch cork borer may be used.
9. To reassemble the halves of the flask, after the pattern is removed, the sprue and handle molds made, and any adjustment required in the sand completed, the lower half of the flask is fitted to the upper half.
10. A ring-shaped weight, of about 3 pounds, with flat ends (an ordinary shaft collar is suggested), is laid on to prevent the halves of the flask from separating during casting. The picture shows the mold immediately after casting.
11. Upper part of the drawing, casting after sand is dusted off. Lower part of the drawing, sprue cut off and handle bent, ready for the next step.

Treatment of Hard Areas.—In the median line of most upper jaws is found the only portion of the mouth which it is said never changes, and which is usually harder than any other portion of the mouth. In constructing bases, resting wholly or partially on the mucosa which covers part of the so-called hard area, cognizance should be taken of the fact that the central area is practically unchangeable, while the remainder will always be to a small degree subject to change. This may be done in the case of a saddle covering all or a considerable portion of the vault, by plotting out on the cast, from a careful examination of the vault (Fig. 340), the outline of the central hard area and, subsequently, in the process of adapting the elliptical bar across the vault, allowing it to stand away from the cast as the judgment of the operator may dictate. This is not necessary for root-supported partial dentures.

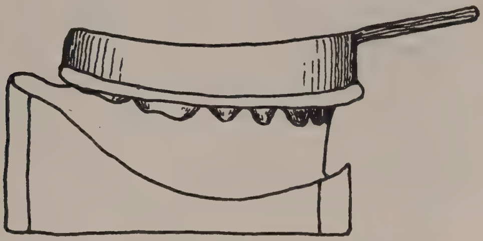


FIG. 334.—Impression half way down the crowns of the teeth taken in plaster.

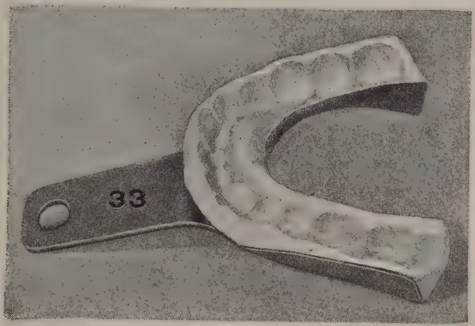


FIG. 335.—Impression removed from the mouth and trimmed.

The Metal Framework.—Combined metal and vulcanite are specially desirable when rebasing is necessary (particularly after recent extractions). One-piece castings (if accurate and otherwise satisfactory) seem particularly suitable for tooth-supported cases, in which the

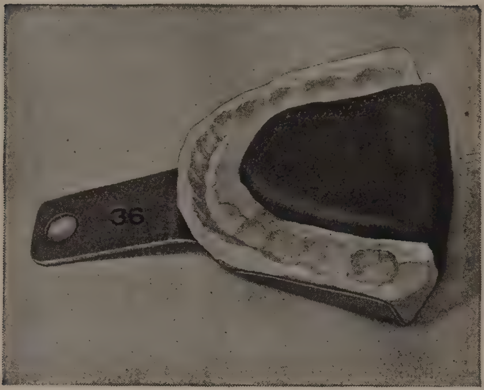


FIG. 336.

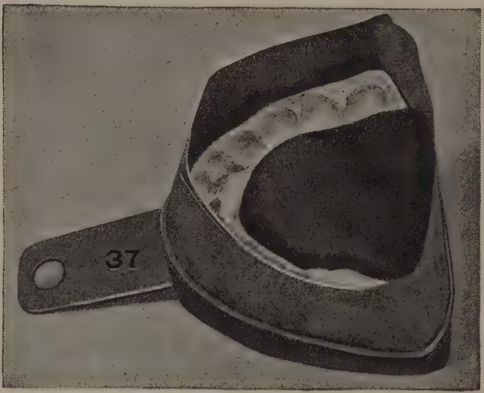
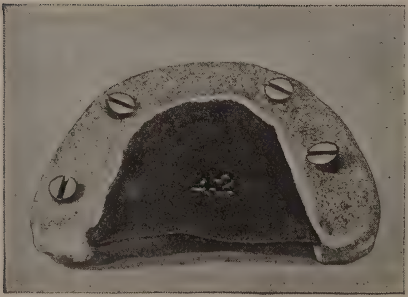
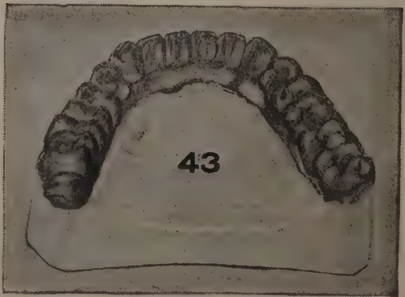


FIG. 337.





FIGS. 336 and 337.—Stages in boxing.

FIG. 338.—Low-fusing metal poured, small wood-screws inserted.

FIG. 339.—Antagonizing cast completed.

FIGS. 334 to 339.—A method of making antagonizing casts of metal.

comparative lack of mobility does not call for a particular degree of resiliency in those parts, notably the clasps, which come in contact with the remaining teeth; while in tooth-supported and tooth-mucosa-supported cases in which an added resiliency is necessary for these members in order to avoid trauma, a casting of all save the clasps, flexible connectors, or similar members requiring resiliency is made (which will permit movement without trauma and which are preferably made from rolled or drawn material, swaged or bent to freehand form) to which the casting is subsequently united by solder. The framework should be periodically inspected for accuracy, adequate retention, unhampered movement (and consequent absence of trauma to the remaining teeth) until its completion in the mouth, or, if the restoration approaches a full denture in extent, may be replaced in the articulator and ground in with carborundum grains in glycerine or similar medium. If heat treatment is involved, it should be given according to the directions furnished with the metals used.

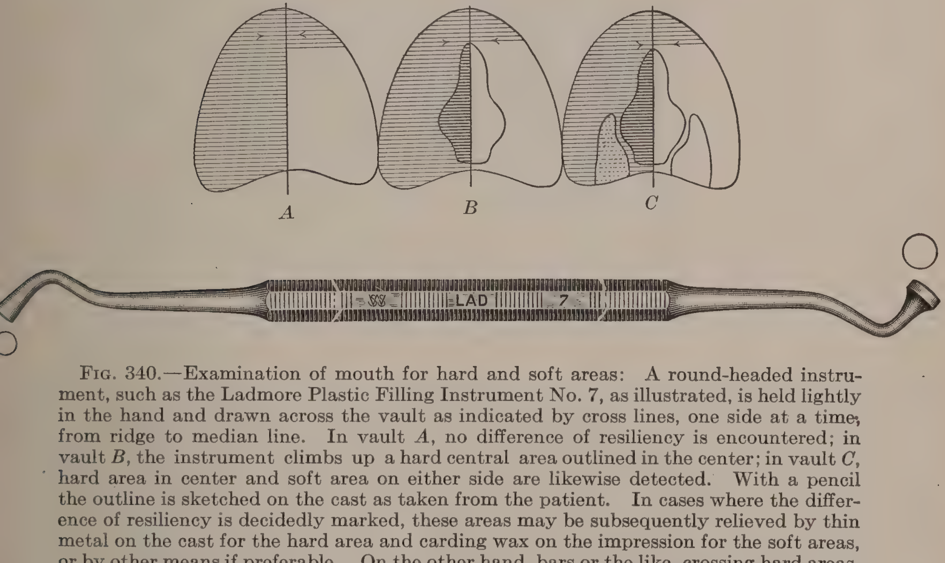


Fig. 340.—Examination of mouth for hard and soft areas: A round-headed instrument, such as the Ladmore Plastic Filling Instrument No. 7, as illustrated, is held lightly in the hand and drawn across the vault as indicated by cross lines, one side at a time, from ridge to median line. In vault *A*, no difference of resiliency is encountered; in vault *B*, the instrument climbs up a hard central area outlined in the center; in vault *C*, hard area in center and soft area on either side are likewise detected. With a pencil the outline is sketched on the cast as taken from the patient. In cases where the difference of resiliency is decidedly marked, these areas may be subsequently relieved by thin metal on the cast for the hard area and carding wax on the impression for the soft areas, or by other means if preferable. On the other hand, bars or the like, crossing hard areas, may be formed or bent to accommodate the difference in resiliency.

Articulation.—As has already been pointed out, under no conditions is the observance of established principles relating to the movements of the jaw, and the use of an adjustable articulator capable of their expression, and harmonious arrangement and formation of the teeth of more importance than in the construction of partial dentures. Interference of porcelain in side movements of the jaw in mastication has resulted in the failure of the teeth supporting or retaining many an otherwise excellent piece of work, because the occlusal trauma is, of

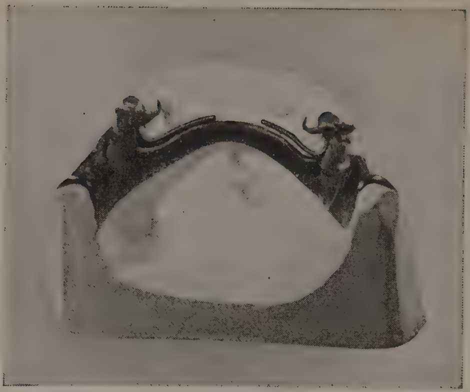


FIG. 341

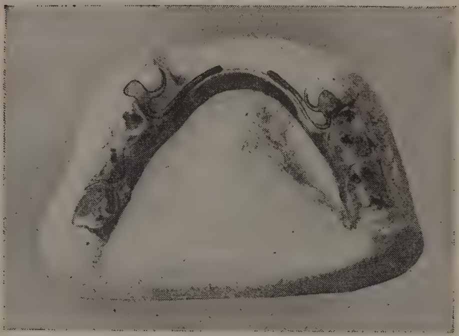


FIG. 342

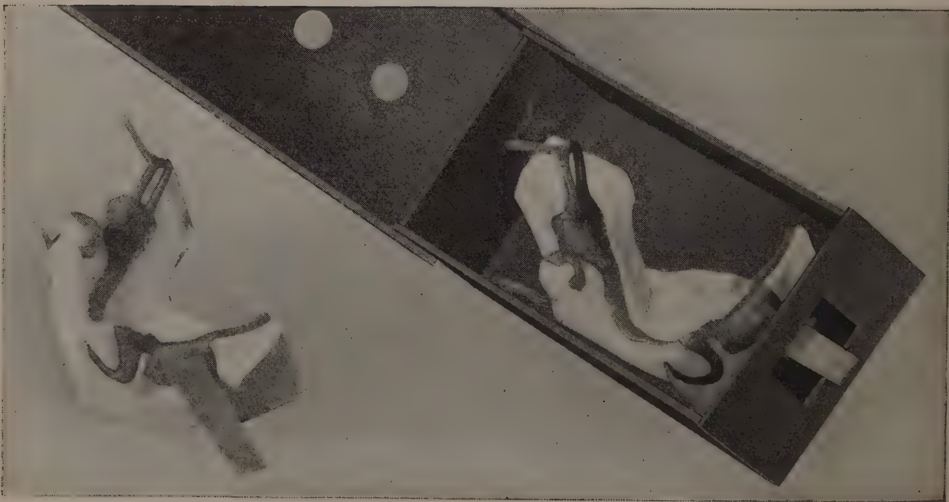


FIG. 343

FIGS. 341 to 343.—Casting and assembling the metal framework. Fig. 341, cast metal base, wrought clasps and flexible connectors, not assembled; Fig. 342, the same, invested, ready to solder; Fig. 343, casting the clasps and framework in one piece for a lower denture with vulcanite saddle. (Ney Technician.)

course, reflected against them; as has non-interference of porcelain or gold accounted for the non-efficiency (if comfort) of other fearfully shapeless pieces of restoration.

In the writer's opinion, an incisor guide with a range of movement in three dimensions, such as that of Sears, is desirable in all cases and quite necessary in many partial denture cases. The presence of remaining natural teeth, essential for the success of the partial denture, often deformed and out of normal position, complicates the placing of the artificial teeth for balanced occlusion—a difficulty not encountered in full denture work, which also, as in full denture work, may be facilitated by the use of the Hanau quint, which expresses the laws of articulation involved in convenient form for practical use. The metal framework serves as an admirable base upon which to erect biting blocks.

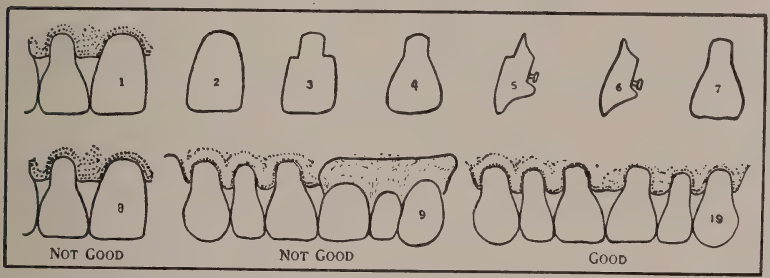


Fig. 344.—Arrangement and alteration of teeth. Anterior teeth: Should there be remaining anterior teeth adjacent to the artificial ones, the latter should correspond both in color and form to the former. Alteration to stock anterior molds is often necessary to imitate recessed gums, wear or other peculiarities. Steps in altering an anterior tooth to show a root are as follows:

1 and 2. Artificial tooth, correct width, but too long.
3. First cut, outlining the mesial and distal sides of the root.
4. Second cut, outlining the mesial and distal sides of the crown.
5. Third cut, outlining the labial side of the root.
6. Fourth cut, outlining the labial side of the crown.
7. Completed tooth.
8, 9 and 10. Examples.

Choice and Arrangement of Teeth.—The close proximity to the artificial teeth of partial dentures, as well as crowns and bridgework, of the natural and living teeth make the problem of color and form the most difficult of all. While the teeth offered to the profession today, resembling as they do the crystallized knowledge of some of the brightest minds in the profession, such as Drs. Williams, Gysi, and others, yet in partial denture construction, alterations in form and color are frequently necessary. The imitation of receded gums, with considerable length of root showing (Fig. 344) different stages of wear, overlapping, erosion, cracks in enamel, characteristic forms varying from ordinary, chalky spots and creases in enamel, brown stains from tobacco, etc., occurring in corresponding teeth on the opposite side of the arch should be reproduced with greatest fidelity. A careful selection, with the articulator and models carrying the assembled framework and with full details concerning the color and form at hand, is necessary, following that in some cases by the use of stones, disks, porcelain polishing materials, and porcelain stains.

Insertion or Installation.—Too much stress cannot be laid on the necessity for proper adjustment at this stage, both before, immediately after, and for a time subsequently, and during the initial stages of the practical use of the appliance. Minor distortions, due to soldering, casting, or from any cause, may here be corrected, and at this stage the final and accurate distribution of stresses on the teeth and mucosa, or both, is provided for, and to a large extent the life history of the remaining teeth is determined. The operation may be performed by the use of thin wax, carbon paper, and spot-grinding.

The service is not complete until all settling has been provided for by rebasing, and all other adjustments are made, and the dentures function effectively without trauma.

Maintenance and repair are occasionally necessary in a standardized manufactured product which (as, for example, a watch) has built into it the findings of centuries of study and progress in that particular branch of technology.

It is therefore reasonable that patients wearing partial dentures in each case specially designed and constructed, and functioning with living parts, should be subject to an occasional oral examination, more especially those wearing partial dentures of unusual design.

Periodic Examination.—A mouth fitted with artificial appliances stands considerable more in need of periodic examination than one without. For example, the breaking of an occlusal rest or the resorption of the ridge may change the whole relationship. A very simple card-index system of notification may be installed, by which the patient receives notice at intervals determined by the dentist. In all cases patients wearing these appliances should at least be given an opportunity for the use of such service.

Instruction to Patient.—All partial dentures, except those which are essential in special cases for preventing the approach of the ridges with less than the normal separation, should be removed at night. All partial dentures are cleansed and the remaining natural teeth cleansed at night, in the morning, and after each meal.

Conclusion.—The writer submits that, in view of the present situation in dentistry, the partial denture field is of highest promise for service to humanity, and commends it with every confidence to his fellow students and practitioners of the dental profession as an opportunity for that unselfish effort toward development which has always been characteristic of the men of dentistry.

CHAPTER X.

VULCANIZED RUBBER AS A BASE FOR ARTIFICIAL DENTURES.

By GEORGE H. WILSON, D.D.S.

REVISED BY

I. LESTER FURNAS, D.D.S.

Vulcanite.—A compound of Caoutchouc and Sulphur.

CAOUTCHOUC.

History.—Caoutchouc is a native Indian name. India-rubber is a name given the material because its early use in Europe was to remove black lead pencil marks from paper. Dr. Priestley, the distinguished discoverer of oxygen, mentions this use in a publication of 1770. Caoutchouc must have been known in America at a very early period, because balls made from the gum of a tree, lighter and bounding better than the wind-balls of Castile, are mentioned by Herrera when speaking of the amusements of the natives of Haiti, in his account of the second voyage of Columbus. In a book published in Madrid, 1615, Juan de Torquemada mentions a tree which yields it in Mexico, describes the mode of collecting the gum, and states that it was made into shoes. More exact information was furnished by a French Academician, who visited South America in 1735. While the Indians used it more than three hundred years ago for water bottles and gum shoes, it was only used in the United States and Europe for erasing pencil marks, until about 1820, when it was applied to water-proofing cloth. As caoutchouc became hard and brittle in cold weather and sticky in hot weather, many experiments were made to overcome this objectionable quality which resulted in the discovery of vulcanite in January, 1839.

Physical Properties.—Caoutchouc is the dried milky juice (called latex) of various trees and plants. A similar gum capable of vulcanization can be obtained from the common milk-weed and other plants of temperate climates, but it is only commercially profitable from certain trees in the tropics. The Brazilian, or Para (a shipping-port on the Amazon river) caoutchouc is the product of several species of Siphonia (nat. ord. Euphorbiaceæ), chiefly Siphonia elastica. Bates says that this tree is not remarkable in appearance; in bark and foliage it is not unlike the European Ash, but the trunk, like that of all forest trees, shoots up to an immense height before throwing off branches. The India-rubber produced in New Granada, Ecuador and Central America is obtained from Castilloa elastica; that of East India from the beautiful glossy-leaved Ficus elastica, now a common ornamental plant in conservatories; that of Borneo from Urceola elastica; and that of West Africa from several species of Landolphia and also Ficus.

After the trees are tapped, the juice (latex) is first received in clay basins, and then is solidified in various ways—as by spreading it out in thin layers and evaporating in the sun or by the aid of artificial heat; or the emulsion is coagulated by the leaves of a kind of vine—a method used in Central America which gives, however, a product inferior to that obtained by evaporation. Of recent years much caoutchouc gum is produced from cultivated trees, and is known as "Plantation Rubber." The cultivated gum is separated from the latex by acid (acetic, citric).

The organization and growth of the "Plantation Rubber Industry" is a most fascinating study. Students interested in the details of this bit of rubber history can spend several pleasant evenings with "The Reign of Rubber" by William C. Geer, A.B., Ph.D. (1922).

The growth of this industry, stimulated by increased commercial demands, is nothing short of amazing. The first statistics were obtained in 1900, when 53,890 tons of native or wild rubber were produced as compared to 4 tons of plantation rubber, while in 1920 we find the plantations put into the market 309,100 tons and native rubber had fallen to 38,915 tons. At this period (1920) we find over 3,321,000 acres under rubber cultivation.

The evaporated product is known as "biscuit." The fresh juice has the consistency of cream, is yellow, miscible with water, but not with naphtha or other solvents of ordinary rubber; its specific gravity is 1.02—1.41; the yield of the gum is about 30 per cent. Pure caoutchouc is devoid of odor and is nearly white; it has the specific gravity of 0.915. The finest quality of caoutchouc is that from Brazil (Para) which has the least impurities; the other South and Central American kinds are of medium quality; East India rubber ranks next, while the African rubber is quite inferior.

Commercial India-rubber is a dark, tough, fibrous substance, possessing elastic properties in the highest degree. At the freezing-point of water it hardens and largely loses its elasticity. The gum is insoluble in water or alcohol, and is not acted upon by alkalies or acids except when the latter are concentrated and heat is applied. It is soluble in ether, chloroform, bisulphide of carbon, naphtha, petroleum, benzol, and the essential oils, and in many of the fixed oils by the aid of heat. Caoutchouc melts at a temperature of 250° F. and does not again resume its former elastic state; at 600° F. it volatilizes and undergoes decomposition.

Purifying.—In the manufacture of India-rubber the first operation is the purification of the crude material. The impure rubber is cut into minute shreds and is washed by powerful machinery immersed in water, which releases the solid impurities. The washed gum is then placed on iron trays and dried in a room heated by steam. The material then undergoes a process of kneading under very heavy rollers, which causes the adhesion of its various pieces to each other and ultimately yields a mass or block of India-rubber so compact that all air-holes, other cells and interstices disappear.

Chemistry of Caoutchouc.—When we consider from a purely chemical standpoint the "milk" from any one of the various rubber-producing plants, the refined caoutchouc, and the process of vulcanization, we find many problems that are yet to be solved by the chemist.

Latex is a milky fluid consisting of water in which is suspended minute globules of rubber. These globules are solid, not liquid. When observed under the microscope, they seem to be somewhat irregular in shape. Since they are solid, we term latex a suspension of solid particles. If these globules were in the nature of a liquid, latex would be an emulsion.

The average chemical composition of latex is about as follows:

	Per cent.
Chemically pure rubber	28
Resins	2
Mineral substances	0.3 to 0.7
Proteins	1.0 to 2.0
Sugars (dissolved in the water)	1.1 to 2.3
Water, about	60

From latex may be obtained 30 to 35 per cent of commercial raw rubber, which contains various numbers of these substances. A gallon of latex weighs 8.17 pounds and contains from 2.45 to 2.85 pounds of raw rubber.

Chemically pure rubber is a hydrocarbon with a formula of C_5H_8. There are several other hydrocarbons that show the same constituents on analysis. However, the rubber hydrocarbon is distinct. It is thought that several of these C_5H_8 groups are polymerized; hence the composition is expressed thus $(C_5H_8)?$.

In studying a picture of the hydrocarbon and the exact relation of each element to the other, it is found that this material is classed with the terpenes $C_{10}H_{16}$; therefore, the formula for rubber is written $(C_{10}H_{16})$.

One can perhaps best think of rubber as a body made up of innumerable round globules of rubber in the form of a microscopic mass of fine shot, each of which is surrounded by a thin film of protective colloid, the protein substance. Thus, raw rubber has a structure. It is not like glass, which is homogenous; not like leather, which is a mass of fibers; or like wood, which is a mass of short, thick fibers.

VULCANIZATION.

Vulcanization, ever since its discovery, has been one of the mystifying problems of the chemist. There are numerous theories advanced, each of which has its group of followers. One thing is definitely known, however, and that is that sulphur in some way actually combines with the rubber molecule. Rubber has a definite affinity for sulphur, and once they have become united there is no known method of separation which will leave the two substances with the same physical properties as before the union. This union is thought by some to be chemical, by others to be physical, while still a third group believe it to be a combination of the two.

At one time it was believed that sulphur would not unite with rubber until the temperature had passed the fusing point of the sulphur, but this has been definitely disproven. Sulphur will unite with rubber at ordinary temperatures; however, in direct ratio as the temperature is increased, the time necessary for vulcanization is shortened. Time and temperature, therefore, become the two important and necessary outside factors giving the proper quality to the rubber composition.

There is another method of vulcanization known as the "cold" process. This is accomplished at ordinary temperatures by immersing pure caoutchouc in sulphur chloride (S_2Cl_2). The results are essentially the same as in the "hot" process, but commercially impractical except in the manufacture of a few specialized articles, such as dental rubber dam, surgeons' rubber gloves, etc.

Composition of Vulcanite for Artificial Dentures.—As the formulæ of the various makes of rubber are "trade secrets" of the manufacturers, our knowledge is limited to the general specifications of patent papers and the writings which detail the experiments of Prof. Wildman and others.

Both the soft pliable and the hard flexible vulcanite are used in the construction of dentures. The essential components of vulcanite are caoutchouc and sulphur, the ratio varying according to the use for which the product is designed. All other ingredients are for coloring or to cheapen the product. The soft pliable variety used in dentistry is known as velum rubber, because its most important use is for vela for cleft palates. It contains sulphur to the extent of about one-fifth of the weight of the gum. Hard vulcanite, sometimes called ebonite, contains by weight one-half as much sulphur as caoutchouc.

Some of the formulæ given by Prof. Wildman are:

DARK BROWN.	Parts.	Per cent.
Caoutchouc	48	66.6666
Sulphur	24	33.3333
RED.		
Caoutchouc	48	44.4444
Sulphur	24	22.2222
Vermilion	36	33.3333
DARK PINK.		
Caoutchouc	48	42.8571
Sulphur	24	21.4285
White oxide of zinc	30	26.7857
Vermilion	10	8.9285

GRAYISH WHITE.	Parts.	Per cent.
Caoutchouc	48	28.5714
Sulphur	24	14.2857
White oxide zinc	96	57.1428
BLACK.		
Caoutchouc	48	50
Sulphur	24	25
Ivory-black or Drop-black	24	25
JET BLACK.		
Caoutchouc	48	40
Sulphur	24	20
Ivory-black or Drop-black	48	40

The standardized formula of the S. S. White Dental Mfg. Co. for all rubbers except white and pink is:

Gum, 50 per cent; sulphur, 16 per cent; dye and filler, 34 per cent.

If pure caoutchouc is burned, there should be but about 3 per cent of dark ash remaining. Sulphur and vermilion (mercuric sulphide) leave no ash, hence the per centum of ash from rubber containing these materials should be less than 3 per cent in the ratio of the amount of these materials to the caoutchouc. Some rubbers leave as high as 60 per cent of ash. It would be reasonable to suppose that the strength would be reduced in ratio to the amount of the ash, but this is not true, as the pure gum and sulphur produce the strongest vulcanite; the red and black are nearly the same strength, although the black rubber will leave a much larger ash than red, because the coloring matter is animal charcoal composed largely of phosphate and carbonate of lime, while the mercuric sulphide would be entirely volatilized. The oxide of zinc and other earthy matter in the pink and white rubbers have a very deleterious effect upon the flexibility and tenacity of the vulcanized rubber, so much, in fact, that these light colored vulcanites are not one-fourth as strong as the brown, red or black.

Physical Properties of Vulcanite.—Vulcanite is hard, flexible, and horn-like in texture. Dr. George B. Snow gives the specific gravity of a specimen of black vulcanite as 1.1974; and that of the same piece before vulcanizing as 1.1333. The specific gravity varies, as it is much affected by the coloring matter, and is also increased by the temperature and time of vulcanization. Caoutchouc expands upon heating. Dr. Snow says: "Rubber expands by heat more rapidly than any other solid body. Its rate of expansion at ordinary temperatures, from 70° to 90° F., is over six times that of iron, about five times that of brass, and nearly four times that of zinc, which is the most susceptible to expansion by heat of any of the metals except mercury. Its rate of expansion is known to increase as the temperature rises, but it has not been definitely determined." In vulcanizing soon after chemical action begins (248° F.), expansion ceases and shrinkage commences, the latter being much affected by the contained foreign matter, by a high or low temperature, and by a long or short time of vulcanization. Its increased specific gravity is due to this shrinkage.

The usual solvents of caoutchouc have but little action upon vulcanite, and no agent which can be tolerated in the mouth has any action upon it. It is susceptible of a high polish. It is very opaque, and, therefore, does not imitate well the appearance of the mucous membrane. It is a very poor conductor of thermal and electrical changes, in consequence of which it is not conducive to the health of the tissues upon which it is worn; and when improperly vulcanized, it becomes so contaminated with decomposing secretions that it is exceedingly offensive. Great care should be used in vulcanizing rubber that is to be worn in the mouth, and the patient should be thoroughly instructed in cleansing it.

New rubber can be added to old vulcanite by reheating; hence vulcanite dentures can be easily repaired. It is unnecessary to add a solution of rubber to vulcanite to aid in its repair, as the solvent has no action upon the vulcanite, only leaving a thin layer of soft rubber to penetrate the pores of the vulcanite, a result better accomplished by heat and pressure.

These terse statements of the physical properties of vulcanite may profitably be amplified:

Specific Gravity.—The specific gravity of vulcanite varies with its composition and method of vulcanization. The following table is sufficiently extensive to elucidate these facts. Pure Para gum has a specific gravity of 0.915, and sulphur a specific gravity of 1.95; therefore, velum rubber containing 1 of sulphur and 5 of gum should have a specific gravity of 1.06; also, hard vulcanizable rubber containing 1 of sulphur and 2 of gum should have a specific gravity of 1.26. The table, page 397, gives four representative dental rubbers, with the coloring matter named in the first column and the specific gravity of a specimen of each in the second column. The third column gives the specific gravity of each vulcanized under a Lewis gas regulator set at 320° F., for one hour and twenty minutes. The fourth column gives the specific gravity of the rubbers vulcanized at the same time as the specimens in the third column, but they were not flasked; they were wrapped in tin-foil and submerged in the water. The second column shows a great variation in the specific gravity of unvulcanized rubbers due to the various coloring materials; the third column shows a still greater variation due to the quantity and conductivity of the coloring material; also this column shows that the coloring material exerts a direct influence upon the denseness of the vulcanite, as shown by the increased specific gravity. The pure black vulcanite was increased in specific gravity 0.0496, the red vulcanite 0.0853, and the gold dust 0.0622; therefore, gold dust shows a condensation over the pure black equivalent to a specific gravity of 0.0126, and the red over the black of 0.0357. The fourth column shows remarkably the action of the heat and its conduction upon the vulcanizing process. The tin and water being far better conductors of heat than the plaster investment, the red and gold-dust vulcanite show a further increase of specific gravity, while the pure black shows a decrease of specific gravity to the extent of 0.0008 less than the unvulcanized rubber. This is explained by the poor internal conductivity of the pure black rubber and the rapid induration of the surface.

This increasing condensation suggests the question: Does revulcanization cause shrinkage? It does. This was demonstrated by revulcanizing six times (under the conditions described in the preceding paragraph) a piece of red vulcanite 66.3 mm. long. Each time revulcanized it was carefully measured and showed an average decrease of .25 mm.; or, approximately, 0.5 per cent for each vulcanization, that is, a total of 3.2 per cent of its length for the six revulcanizations.

Table of specific gravity.	Coloring material.	Before vulcanized.	After vulcanization in flask.	Vulcanized in tinfoil, not flasked.
Para caoutchouc	Smoke	0.915		
Sulphur	....	1.95+		
Mercuric sulphide	....	8.2		
Velum rubber (Doherty's)	Smoke	Less than 1.0	Less than 1.0	
Pure black rubber (Doherty's)	Drop black	1.1523	1.2019	1.1515
Bow spring (White's old formula)	HgS	1.6410	1.7263	1.7421
Gold dust (Traun's)	Aluminum powder	1.1321	1.1943	1.1972

Dr. Snow states graphically the relative expansion of vulcanite and certain metals. Other authorities give the coefficient of expansion as follows:

Cast iron	0.0000055
Zinc	0.0000140
Mercury	0.0000998
Vulcanite	0.0000636

Thus it is seen the authorities (Heil and Esch, and Thorpe) for these figures make the expansion of vulcanite more than four times as much as for zinc, the most expanding of the solid metals.

Textbooks state that rubber expands until vulcanization begins and then shrinkage takes place. This is true. The author devised a special vulcanizing apparatus for demonstrating the expansion and shrinkage of vulcanization. It consisted of a brass flask open at the top and a plunger cover with a hole through which a thermometer is placed in contact with the rubber. The flask is placed in an open receptacle filled with glycerin nearly to the top of the flask. A 2-pound weight is placed upon the plunger cover, also an upright making connection with a recording needle which enlarges ten times. Heat is applied by an electric heater. Red rubber was placed in the flask and the following record obtained: From room temperature to 200° F., $\frac{1}{8}$ inch, and from 200° to 250° F.,1 inch. The needle remained stationary for a short time, then dropped back $\frac{1}{8}$ inch and so remained until the end of vulcanization (320° F., one hour), after which it moved back about $\frac{3}{16}$ inch. As both rubber and sulphur melt at approximately 250° F. and vulcanization begins at 248° F., it is evident that expansion continues until the ingredients are melted and union begins, and that the shrinkage and contraction are greater than the expansion, as shown by the increased specific gravity in well-vulcanized rubber. However, the improvised recording vulcanizer did not record perfectly the shrinkage of vulcanization because the indurating rubber had greater resistance than the weight applied. The shrinkage took place in itself, in the direction of least resistance, thereby forming several large spaces. There was no evidence of gas formation associated with these spaces as so evident with porous vulcanite when "something has gone wrong."

A practical application of these physical properties cannot be made until after a study is made of the technic of vulcanization, to which attention is now given.

How to Vulcanize Rubber.—Having learned that rubber expands excessively in heating up to the vulcanizing temperature and shrinks during vulcanization; also that its induration is the result of a combination of the caoutchouc and sulphur, and that a small amount of hydrogen sulphide may be formed, but that it is in no wise an essential factor of vulcanization; and further, that there is a diversity of opinion as to how rubber should be vulcanized, the author instituted the following experiments as a means for establishing a rational method for vulcanization:

A glass marble 31.5 mm. in diameter was ground so as to form two parallel flat surfaces 25 mm. apart. This was used as a model and flasked in a vulcanite flask with French's regular dental plaster. Five of these molds were made and excess spaces cut approximately $\frac{3}{16}$ inch about the mold, but without gateway connections. No. 1 was filled with bow-spring (old formula) rubber, the flask closed and held firmly together in a Donham clamp (Fig. 373), and vulcanized under the Lewis gas regulator set at 320° F., for one hundred minutes. It was not removed from the vulcanizer until it normally cooled to room termperature. The flask had opened approximately $\frac{1}{8}$ inch. The specimen was sawed through the center of the flat surfaces and disclosed a dense rim of approximately 4 mm. thickness, a finely spongy interior, and emitted a strong odor of hydrogen sulphide. The cross-section measured 28.2 mm., that is, had increased in size 3.2 mm. Mold No. 2 was treated in every way the same as mold No. 1, except it was vulcanized for three hours. It presented the same general aspect except darker in color, and measured but 26.6 mm.; a shrinkage of 1.6 mm. (or one-half the amount of expansion of No. 1), due to the eighty minutes' additional heat. Mold No. 3 was filled in like manner, but bolted firmly together with three bolts, and subjected to heat the same as No. 1. The flat surfaces of Nos. 1 and 2 specimens were not distorted, while No. 3 was slightly convex. The plaster investment was more or less crushed and compressed, as shown by the surface of the rubber; the internal appearance was the same, but it had expanded to a diameter of 28.6 mm., showing great force in the expansion. Mold No. 4 was filled in like manner, tightly closed in a Donham clamp and vulcanized slowly; that is, the Lewis gas regulator was set at 280° F. for one hour, at 290° for forty minutes, and at 300° for two hours. The section of this specimen showed evenly dense vulcanization throughout its mass, but excessive skrinkage. At the periphery of the flat surface it measured 23.4 mm., and at the center 22.2 mm. Thus showing a difference of 6.4 mm. in thickness of the specimens, due to the methods of applying heat. Mold No. 5 was filled with two thicknesses of red rubber upon one side and the balance filled in with a good quality of plain pink rubber. This was placed in the Donham clamp and the Lewis regulator set at 320° F., for ninety minutes. There was slight excess rubber forced out, but no distortion of the flat surfaces. The section measured 25 mm., and showed but slight porosity at its center.

Fig. 345 shows graphically the model and five vulcanite specimens.

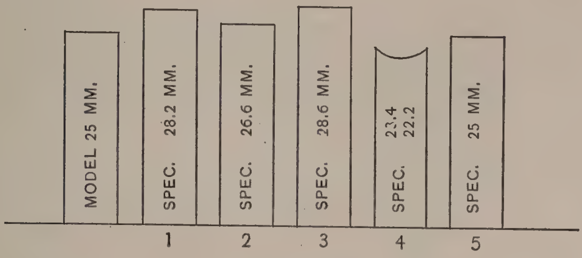


Fig. 345

The rationale of these experiments is arrived at by a study of the physical and chemical properties of the ingredients. The essential constituents of dental rubber are caoutchouc and sulphur, both exceedingly poor conductors of heat, fusing between 239° F. and 250° F., and begins to combine chemically at 248° F. Both constituents expand excessively by heat, but their mixture begins to shrink with chemical union, and continues shrinking indefinitely under vulcanizing heat.

It is a physical law that: Force of expansion by heat is in the ratio to the denseness of the substance. Therefore, the force of expansion of solids and liquids is very great while that of gaseous substances is comparatively small. It is evident that the small amount of hydrogen sulphide formed in the vulcanization cannot account for the great force generated, but that it is due to the expanding dental rubber.

The relatively large mass of rubber used in these experiments introduces no constant, but the magnitude makes the phenomena appreciable while a smaller mass would not be so readily comprehended. In these experiments (Nos. 1, 2, and 3) the surface of the rubber was rapidly raised to 320° F., causing the surface to expand and harden much in advance of that within. As the heat advanced more and more, expansion was taking place and a thicker and denser surface of vulcanite was forming until there was no more rubber to expand; and, as the forming vulcanite shrinks, a vacuum must be created, because the internal melted dental rubber must shrink in the direction of least resistance.

Practical Vulcanization.—1. A plaster compound cast.

2. All wax model dentures should be reduced to the required thickness, and preferably encased in tin-foil.

3. Flasked with a good dental plaster, excess space encircling the mold, but no gateways.

Battersea Public Library.

4. The flask well warmed, but not above 212° F. The mold evenly packed with red or black rubber, or a combination of the two, but in no case should the high-grade rubbers be more than 4 mm. in thickness (danger thickness); all space not filled with the base rubber is to be filled with pink rubber. A layer of pink rubber should be used over the labial and buccal surfaces for esthetic purposes.

5. The flask may be cautiously nearly closed under pressure, but the final closure is in the vulcanizer under the spring. Bolts and rigid flask presses are dangerous.

6. A spring should be used that will not permit of a pressure exceeding 500 pounds, and also have a long range of resiliency. A volute form is best (Fig. 373).

7. Vulcanization should be in steam and at high temperature and short time, that is, the gas regulator should be set at 320° F. for one hour and twenty minutes. As the heating qualities of the gas of various cities fluctuate, the time element must be determined by each operator for himself. However, sufficient heat should be applied to reach the maximum temperature in approximately twenty-five minutes, not varying more than five minutes either way; then the high heat should be maintained until the rubber, where not more than 1 mm. in thickness, is very elastic, but hard enough to readily take a high polish. This result will be accomplished in many offices in one hour and twenty minutes (that is, twenty-five minutes to heat up and fifty-five minutes sustained high temperature); others will require a longer or shorter time.

The reason for the elastic spring and short time method of vulcanization is: The expansion cannot be controlled as to its amount, because it must reach its maximum of expansion before induration can begin. The effect of the expansion is influenced by the method of retention by bolts or by spring clamps, and whether vents are or are not provided.

The amount of shrinkage is very much influenced by time; the longer the time the dental rubber is subjected to vulcanizing heat, the greater the amount of shrinkage. High heat causes rapid hardening of the surface and the internal pressure during the hardening and shrinking of the surface causes a close adaptation of the vulcanite to the sides of the mold and teeth; then as the internal shrinking takes place, it will be toward the hardened surface. By the use of a flexible spring the expansion is controlled so that it cannot do harm, and if sufficient expansion has taken place to open the flask, the spring will follow up the shrinkage until the flask is again closed, after which further shrinkage is not under control; whereas if bolts and gateways are used the expansion forces out a part of the rubber, and when shrinkage takes place there is less material in the mold. Therefore rubber tightly shut in the flask, with its expansion and shrinkage controlled by a suitable spring, and rapid surface hardening, due to the high heat (320° F.) at the surface and a decreasing degree of heat toward the center of the mass of rubber *because of its poor conductivity*, is the logical and scientific method of vulcanizing all dental rubber. However, this method is best adapted to comparatively thin masses of rubber; all thick places in vulcanite appliances should be filled with an indifferent material, therefore such places are filled with plain pink or white rubber.

If the flask is to be bolted, then gateways opening into vent spaces are imperative. Also the pink rubber is even more important than when vulcanizing under a flexible spring. If bolts are used the flask should be completely closed before the flask is placed in the vulcanizer. This closing of the flask is probably more safely done in boiling water; whereas, by the elastic-spring method it is not necessary that the flask shall be entirely closed. The plaster in the flask should be kept out of water, and therefore will have much more resistance to the pressure of the expanding rubber and to the force of the spring. The vulcanizer should contain 2 to 5 ounces of water.

ADVANTAGES AND DISADVANTAGES OF VULCANITE AS A BASE FOR ARTIFICIAL DENTURES.

Advantages.—1. It is easy of manipulation; it can be molded into any form, and it becomes, upon proper vulcanization, very strong, tough, flexible, and elastic. It is repaired with equal ease.

2. It is the lightest of all substances used in the mouth; its specific gravity is from 1.15 to 1.75, while aluminum, the lightest metal suitable for use in the mouth, has a specific gravity of from 2.5 to 2.7.

3. It is inexpensive, both as to cost of material and labor in construction, thus bringing it within the reach of patients unable to afford metal plates.

4. Difficult cases can be easily and perfectly restored.

Disadvantages.—1. It is a very poor conductor. It prevents the proper radiation of heat from the mucous membrane over which it is placed, thereby leading to excessive resorption of the hard tissue and lowering the vitality of the soft tissue, in consequence of which they are more subject to the action of irritants.

2. The physical property of continued shrinkage under vulcanizing heat is certainly a disadvantage, because it interferes with perfect adaptation when revulcanized.

3. Bacterial growths multiply much more readily on vulcanite bases than upon metal bases.

By some vulcanite is considered as porous. This is undoubtedly an error. In 1869 a committee of the Pennsylvania College of Dental Surgery, consisting of Professors Wildman, Buckingham and Truman, were appointed to investigate and report upon Dental Vulcanite. In part the report states: "In repeated examinations made to test this (porosity), by high power of the microscope, nothing resembling pores has ever presented. It has been found impossible to procure a section thin enough to transmit light, although ground to extreme tenuity. Examined as an opaque object, it presents a homogeneous mass, with no appearance of openings for the admission of fluids; nor have we ever been able to discover moisture in specimens that have been worn. That it is impenetrable to moisture in the ordinary process of wear, is apparent in the non-increase of weight." In correspondence with Professor Truman since the former edition of this book, he writes, that he has had no evidence to change the conclusion as presented in the report published in the *Dental Times* of July, 1869. Further than this, the process of manufacture of rubber requires compression between very powerful rolls, and its physical property of increasing the specific gravity by vulcanization would favor great denseness.

Recent experiments by Dr. Snow seems to show a small amount of absorption of water by the dental rubber now used. Therefore, a conclusion should not be formed until further evidence is adduced.

Red and pink rubbers are considered injurious because of their coloring matter, vermilion (mercuric sulphide). This criticism is unjust, because pure mercuric sulphide is insoluble in water, alcohol, alkali, and all acids except nitrohydrochloric acid, which under no condition should come in contact with red or pink vulcanite, as this acid converts HgS into $HgCl_2$ (corrosive sublimate). It is evident that the heat of the vulcanizer cannot decompose vermilion because in its manufacture the ingredients are subjected for many hours to a temperature approximating 1200° F.; therefore, it would be unreasonable to expect a temperature under 400° F. to undo the work of three times as great a heat. However, it is possible that free mercury may be in red rubber, but if so it is because it was placed there in a poor quality of vermilion; therefore the dentist should use only the high-grade rubbers of reliable manufacturers.

CONSTRUCTION OF VULCANITE DENTURES.

The history and the physical and chemical properties of caoutchouc and vulcanite have been treated at considerable length, under the belief that with this information fully set forth, the student will pursue the study of the technic of the construction of vulcanite dentures more intelligently and with more interest and profit.

It is important in dental technic that every step in the series of an operation be carefully and accurately performed, otherwise the desired results cannot be obtained.

There are two general methods of constructing vulcanite dentures, which we shall name the Double Vulcanization Method and the Single Vulcanization Method. The first method is best adapted to all full cases where contour restoration of the gum tissue is required; also to some partial cases. The second method is best adapted to full cases where little or no gum restoration is required and to the larger portion of partial cases.

FULL UPPER: DOUBLE VULCANIZATION METHOD.

The operation consists of taking the impression, making the cast, forming a base-plate, and finishing the maxillary surface thereof; of obtaining the occlusion models, arranging the teeth and proving the contour and expression; of preparing the case for flasking, packing, vulcanizing, and finishing.

Impressions.—It is imperative in vulcanite work that a perfect impression be obtained. The technic of this operation is described in former chapters.

The Cast.—For many years plaster of Paris was used to the exclusion of practically all other mediums for cast construction, but recent investigation has proven that it is totally inadequate to meet the necessary demands.

During the process of vulcanization, the cast is subjected to high temperature plus steam penetration which causes a general breaking down and disintegration of the mass. This may be called the "temperature deterioration point" and varies greatly with different cast materials. The pressure necessary for complete closing of the flask causes a certain movement of the rubber in the matrix. This may be called the "temperature flow" of the rubber and varies with different base rubbers.

Inasmuch as the temperature deterioration point of plaster of Paris begins in the vulcanizer at about 215° to 220° F. and the average temperature flow of most base rubbers is around 270° F., it will be noted that a cast constructed of plaster of Paris will have deteriorated and broken down long before the base rubber has seated itself in the details of the matrix. In other words, the vulcanite base is formed over and around a disintegrated cast which is changed under the pressure.

Another reason why plaster of Paris should never be used for a cast over which to vulcanize is that it cannot withstand the heavy pressure to which it is subjected during the process of flask closing. Where bolt pressure is used in closing the flask, it has been demonstrated that pressures up to 8000 pounds per square inch on the face of the cast are not uncommon. Even our improved and more modern cast materials cannot withstand this amount of pressure much less plaster of Paris.

Healy's artificial stone or the Ransom & Randolph Model Stone (Improved) are much better for this work than plaster of Paris. These materials are used very much like plaster of Paris, but always without accelerators, and are mixed much thicker. They should be kneaded in the hands until about the consistency of glazer's putty and then packed in the impression and allowed to set for *at least* three hours before separation is attempted.

It is better practice in vulcanite work to carve and make additions to the cast for equalizing the pressure of the denture than to alter the impression. However, if the impression is properly taken with either plaster or compound, carving and addition are rarely indicated. The carving can be done as described in the chapter on this subject. Obviously, additions to the cast must be made of a material that will stand the heat of the vulcanizer. Tin is best for this purpose as it does not discolor the rubber. The S. S. White No. 60 tin-foil, which is about 0.005 of an inch thick, is well adapted for this use, and can be applied in one or more thicknesses by attaching each layer with sandarac varnish. Thicker pieces of tin can be made by rolling out bar tin, after which they are annealed by placing a few moments in boiling water. This tin plate is fastened to the cast by $\frac{1}{8}$ inch tacks or brads, or is retained by the tin-foil used for finishing the maxillary surface.

The Base-plate.—The cast having been properly prepared, the base-plate is made by warming and evenly forming a sheet of this base-plate wax over the cast. With a warm wax spatula the excess wax is cut off, permitting the wax pattern to extend one-sixteenth of an inch farther over the sides of the cast than it is desired to have the plate extend when it is finished. The hot spatula is then passed around the edge of the wax which causes it to adhere to the cast. The base-plate may be very much improved by adding a small roll of yellow wax to the entire periphery (except the palatal border of the upper base-plate). This border wax is united and shaped to the base-plate with a hot wax spatula. The cast with the wax base-plate is now flasked in a Star or Wilson flask (Figs. 372 and 373).

Flasking the Base-plate.—The flasking is done with regular dental plaster, and should be so arranged that the separation of the two portions will be at the periphery of the wax. The plaster in the first section of the flask must be coated with a separating fluid. Any of the various liquids used for separating plaster may be used, except oil, which should never be used in rubber work, as it has a deleterious effect upon the vulcanizing rubber. After the flask is filled, it should stand until the plaster is thoroughly hard. French's regular dental plaster will require not less than twenty minutes and the slower-setting plasters from thirty to forty-five minutes. If the surface of the cast, covered with wax, present no undercuts, or, but slight ones, the flask may be opened without warming; but if there are undercuts of any magnitude, the flask should be heated and placed in a stew pan or any convenient receptacle and covered with cold water. The water is heated to ebullition, when the flask is removed from the water and separated. The wax will be sufficiently softened to permit of easy removal. It is desirable to have all wax removed without melting, but should a portion of the wax be melted upon the cast it should be washed away with boiling water in which sodium carbonate (sal soda) is dissolved, about a dessertspoonful to a quart of water. Some experience will be required to know when to take the flask from the water. Large cases in which the wax is very near the sides of the flask may require opening just before the water reaches the boiling point; while small cases in which the wax is much nearer the center of the flask may require boiling for a minute or two.

An excess space to receive the superfluous rubber should be cut in the cast portion of the flask, beginning $\frac{1}{8}$ inch from the mold and extending to the rim of the flask.

Finishing the Maxillary Surface of the Base-plate.—The surface of the cast should now be coated with a material that will give a hard and smooth finish to the maxillary surface of the vulcanite. There are three general methods, which are known as the tin, the liquid-silex, and the Glasslene methods.

The Tin Method.—This method is preferable as it gives a smoother and denser surface to the vulcanite, especially if any wax has been melted into the cast. A sheet of No. 4 or No. 6 tin-foil is nicely fitted over the cast with the thumb and finger. It is then removed and the excess of tin cut away with sharp scissors, as indicated by the imprint of the edge of the cast upon the tin. The cast is now coated with sandarac varnish, and when it becomes sticky the tin is at once replaced and firmly pressed and gently rubbed with a wad of soft tissue paper until there is perfect adaptation to the cast. The tin should be rubbed until it has a well burnished surface. It is important that the tinned cast be coated with a lather of soap. This is accomplished by wetting a soft bristle brush and rubbing it upon a cake of soap and then upon the palm of the hand, until a smooth lather is formed, which is applied to the tinned surface; or a thin wash of Johnson's ethereal soap may be used. If the soap is not applied, the tin and vulcanite will adhere very strongly and can only be separated by dissolving the tin with mercury or hydrochloric acid.

The Silex Method.—The liquid-silex method has the advantage of being more easily applied, and if the surface of the cast is entirely free of wax or oily substances, it will give nearly as good results. A clean ox-hair or camel's-hair brush is dipped into the liquid-silex and is then applied to the cast. It will be necessary to occasionally dip the brush into water, so that the silex may be well diluted and evenly applied. The excess of silex should be absorbed with a cloth. Another method is as follows: While the thin silex is still moist upon the cast, dust with talcum powder and when dry, rub carefully with a soft cloth. The liquid-silex bottle should be kept well corked and no particles of plaster be permitted to get into it, as they will precipitate and spoil the silex for use. The brush must be well washed each time it is used.

The Glasslene Method.—Glasslene is a trade name given to a preparation of cellulose that is furnished in very thin sheets. When rubber is vulcanized in contact with this material, it leaves a smooth, clean, and dense surface very similar to that produced by tin-foil. It has the advantage over tin-foil in that it is much more easily removed from the vulcanite base.

Its chief disadvantage lies in the fact that it is more difficult to adapt to the surface of the cast without creases and wrinkles. These can be partially prevented if the Glasslene sheet is first moistened in warm water before applying.

Packing the Base-plate.—The cast having been coated with either the tin, liquid-silex, or the Glasslene, the counter portion of the flask is placed plaster side down, upon a piece of sheet iron over the gas stove. The cast portion of the flask is placed upon the sheet iron with the cast downward, and one edge resting upon the other section of the flask so that the cast does not touch the sheet iron; heat is applied for three or four minutes or until the plaster is as hot as the fingers can bear when pressed upon it. The case is then removed from the sheet iron and a piece of brown or black rubber large enough to cover the cast is placed in the mold in the flask. If there is any doubt of the rubber filling the mold, an extra piece should be added. The two portions of the flask are placed together and gently pressed in the flask press until closed. (See Figs. 377 to 379.)

Vulcanization of the Base-plate.—The flask is then clamped or bolted and placed in the vulcanizer (see Figs. 381 to 391), and sufficient heat is applied to raise the temperature to 320° F. and sustained for fifty minutes. When the flask is cold the case is removed and all plaster cut and brushed away.

Finishing the Base-plate.—The periphery of the base-plate is trimmed with a vulcanite file to the desired outline, and the labial, buccal, and lingual surfaces are scraped, so as to have a clean, fresh-cut surface for the attachment of the teeth and contouring rubber.

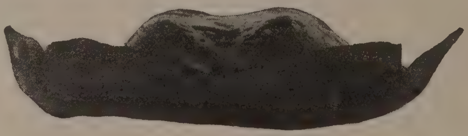


Fig. 346.—The base-plate.

Obtaining the Occlusion Models.—The base-plate (Fig. 346) is placed in the mouth and the patient is instructed to swallow; when, if the conditions are favorable, it will be firmly retained. With the index-finger, pressure should be exerted upon every portion of the base-plate to see if this tends to dislodge it; and if so, the cause should be noted to see if the fault can be corrected. It is to be observed if the labial and buccal fræna are sufficiently relieved, that the plate at the canine eminence is as high as can be worn, and that the distal edge of the plate does not extend too far backward. If there are faults that cannot be corrected a new impression should be taken and the work started again. In some cases the soft tissues are so very tense that adhesion will not take place at once. In such cases the index-finger of the left hand should be placed against the vault of the base-plate and the test made as before,—when, if the base-plate sets firmly at every point and the peripheral line is correct, the operator may be assured the finished denture will adhere after it has been in the mouth a short time.

A satisfactory base-plate having been obtained, wax should be formed over the alveolar ridge of the base-plate to restore the contour of the gum and the outline of the teeth, by repeatedly trying in the mouth and adding to or taking away the wax until the desired effect is produced (Fig. 347). The objects sought are: (1) that the lips and cheeks be held in as near the normal condition as possible; (2) that the wax be built the full length of the lip, thus indicating the incisal line of the teeth; (3) that the occlusal edge of the wax be carved to receive a slight imprint of the cusps and incisive edges of all the lower teeth, and (4) that a line be drawn in the wax to indicate the median line of the face and also the high lip line at the highest point at which the patient can elevate the lip by muscular action.

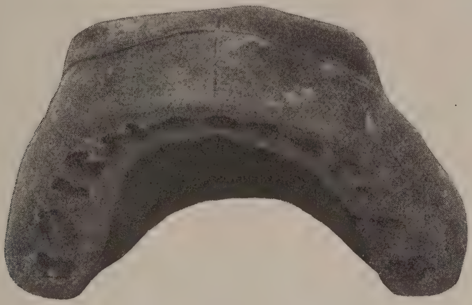


Fig. 347.—The base-plate with wax added used for the bite-plate.

Sufficiently well-softened modeling compound should be placed in a lower tray and a perfect impression of the occlusal and incisive surface and at least one-half the length of the lower teeth be taken. This impression may be filled with regular dental plaster or better, artificial stone, because of its great hardness.

Teeth of suitable size, form and color (see Chapter VII), should now be selected and the patient dismissed.

The base-plate with its wax occlusion model and cast of the lower teeth should be adjusted upon an anatomical articulator (Fig. 348). If there are heavy undercuts in the base-plate, they should be filled in with soft wax, but if the undercuts are not sufficient to interfere with its easy removal from the supporting cast, no wax will be needed. The cast of the lower teeth should be adjusted to the imprints of the teeth in the occlusal edge of the wax model and sufficient regular dental plaster mixed to fill the base-plate and attach all to the articulator. Attention should be given to placing the case properly upon the articulator. The Snow face-bow furnishes a good means for accurately adjusting the case. Fig. 349 shows wax model removed.

Arranging the Teeth.—A section of the wax model extending from the median line and the high lip line backward to the first molar, upon one side only, should be removed (Fig. 348). Arrange the teeth in this space so as to restore the contour of the removed wax, and at the same time follow the instructions in Chapter VII. Wax should be melted about the lingual and cervical portion of the teeth to securely fasten them. The remaining segment of wax representing the molars should now be removed and the teeth secured in their position. The opposite side is treated in like manner. The contour of the gum is restored by aid of a wax spatula and the addition of wax where needed. The wax can be nicely smoothed by passing it through the Bunsen

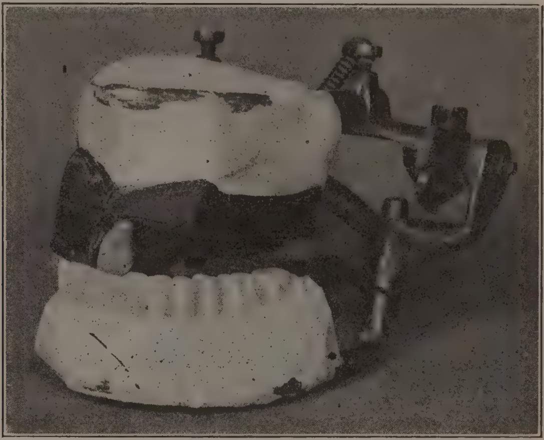


Fig. 348.—Casts mounted upon articulator: wax removed for setting up of teeth on one side.

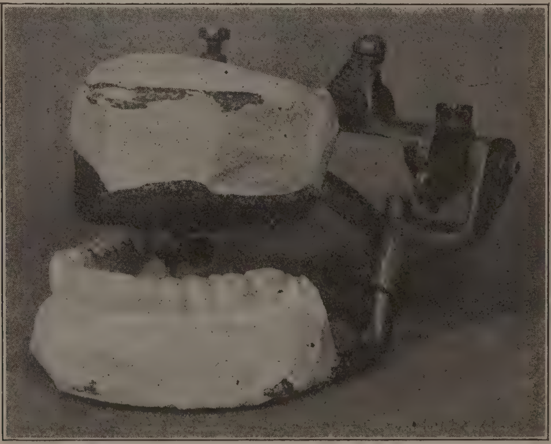


Fig. 349.—Base-plate on articulator with wax removed.

flame. The teeth may be cleaned of wax by using a cloth wet with chloroform. The case should now be taken from the articulator. If any wax has been placed upon the maxillary surface it must be removed.

Proving the Antagonization, Contour, and Expression.—The case should be placed under the faucet to chill the wax and moisten the maxillary surface; it is then placed in the mouth. The occlusion must first be considered. Examine the molars and bicuspids with a mouth mirror and use a thin spatula blade to determine if there is equal pressure upon both sides. The antagonization can be inspected by requesting the patient to carefully close the teeth in various positions. The incisors are studied by taking a position in front of the patient, and requesting the patient to raise the upper lip, thus observing the location of the median line and the inclination of each of the six anterior teeth (see Fig. 367). The contour is proved by studying the face. Standing at the side of the patient observe the profile and see that the upper lip is in harmonious relation to the lower, also that the lip has its normal fulness throughout its length (see Figs. 365 and 366). If the patient has been without teeth for a number of years, or has been wearing dentures in which the bite was abnormally closed, it may be noted that the upper lip has become somewhat shortened and thickened. Where this condition is present it may be advisable to select teeth that are slightly too long in appearance because a correctly constructed denture will have a tendency again to place the lip under normal tension and it will again assume its original position. In that case the teeth will appear more natural. If this precaution is not taken, when the lip again assumes its normal condition, the teeth will be completely

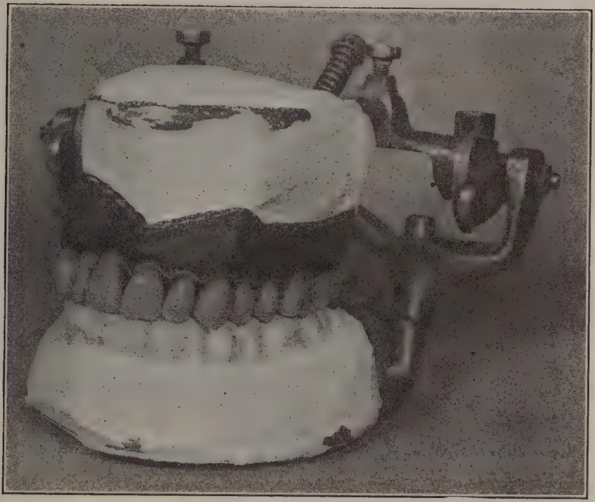


Fig. 350.—Teeth set up and strings in place.

hidden and the patient will appear edentulous. The operator should again take a position in front of the patient. Attention should be given to the incisive fossæ and canine eminences, and especial attention be given to the triangles formed by the wings of the nose and cheeks which are influenced by the apices of the canines. If it is desirable, the cheeks can be contoured to a limited extent by the addition of wax contours (plumpers) over the molars. Having obtained the desired results in a state of rest, the operator should engage the patient in conversation and observe the effect. The case is now cleansed of the secretions of the mouth by holding under the faucet and drying with a cloth. If any of the teeth are loose, they must be securely fastened, and the wax smoothed without changing its form.

The double vulcanization method is especially adapted for restoring the contour and expression, because this work is done in wax, when the wax form can be easily and perfectly reproduced in vulcanite.

Preparing the Case for Flasking.—If the teeth have been set up with pink paraffin, sticky wax or Kerr's setting-up wax, the surface should be finished with pure yellow wax, as it is very difficult to attach tin-foil to the hard waxes. Strings are used for outlining the festoons and periphery of the gums. The object of the festooning string at the cervical portion of the teeth is to give the proper thickness to the margin of the gum. The string used for this purpose is waxed dental floss, twisted very hard, doubled, and twisted again. In doubling, the loop will show the direction in which it should be twisted the second time. Wax the string well with softened wax and apply it by grasping the left heel of the plate between the fingers and thumb of the left hand, with the occlusal surfaces of the teeth upward; place one end of the string at the distal surface of the second molar, pressing it gently into the wax; outline the margin of the gum, using the wax spatula to carry the string well into the interproximal spaces. The peripheral string should be well-waxed wrapping twine, placed at the outer edge of the wax, and secured in place by melted wax made smooth with a hot spatula (see Figs. 350, 359 and 369). If the roll of wax was added to the periphery of the pattern base-plate the peripheral string is not applicable. The vulcanite base-plate formed with the thickened rim is the preferable method, as it provides greater rigidity.

The next step is to cover the buccal and labial surfaces with a strip of No. 60 tin-foil. Instructions are necessary in applying the tin over the strings. The No. 3 instrument of the Evans set of carvers (Fig. 370) is especially adapted for adjusting the tin-foil. The strip of foil is placed over the wax and teeth and pressed as closely as possible into position with the fingers. Hold the work in the left hand, seize the ivory-pointed instrument by the hand grasp, rest the thumb upon the occlusal surface of the second molar and burnish the tin closely to the tooth and against the festoon string. Continue this operation with all the teeth. With a sharp chisel cut away the excess of tin upon the teeth to within one-sixteenth of an inch of the festoon string (see Fig.

351). After readjusting the tin about the teeth, the metal must be burnished over the string to give the desired thickness of the gum and the contour of the festoon. This is done by holding the plate and burnisher in the same manner as before. The instrument must extend one-sixteenth of an inch behind the string and at the same time must rest upon the body of the tooth while pressing the tin down over the festoon string. By this means a proper thickness and contour is given the margin of the gum, without forming an unnatural beaded edge. After all the teeth have been thus treated, the position of the plate should be reversed in the left hand, so that the thumb of the right hand may rest upon the periphery of the plate while burnishing the tin from the festoons toward the edge of the plate. With a pair of sharp curved scissors trim the tin flush with the peripheral string, but do not permit it to overlap the vulcanite base-plate (see Fig. 351). The case is now ready for tinning the lingual surface. Use No. 60 foil and if the vault is a high one, slit the tin from the middle of one side to the center. Place the inner end of the slit over the middle of the vault, and one edge of the slit along the median ridge to the incisor teeth; press the side of the foil gently against the wax and teeth; press the other half of the tin in the same manner into position, permitting the slit portion to overlap the first half. With sharp scissors trim the tin nearly down to the teeth. Remove the foil and place it upon a plaster or metal cast[1] having well-defined rugæ and burnish the rugæ into the foil. Remove the foil, turn it over and fill the impressions of the rugæ with wax, also smear the remainder of this surface with a thin layer of wax; now replace the waxed surface against the vault of the plate and nicely adjust with the fingers. The tin must be securely burnished against the teeth. The lingual contour of the teeth[2] is reproduced by burnishing their forms in the tin. (See Fig. 352.)

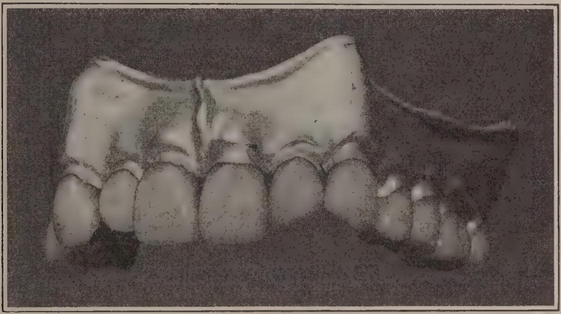


Fig. 351.—Tin-foil applied to labial and buccal portions of denture.

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[1] A suggestion of Dr. A. DeWitt Gritman of the University of Pennsylvania.

[2] In the International Dental Journal for August, 1905, Dr. William M. Fine describes and beautifully illustrates his method of carving the lingual contour of the teeth.

Flasking.—A flask with a narrow rim is imperative. The Star flask will do very well, but one made by the Cleveland Dental Manufacturing Company, called the Wilson flask, will better serve the purpose.

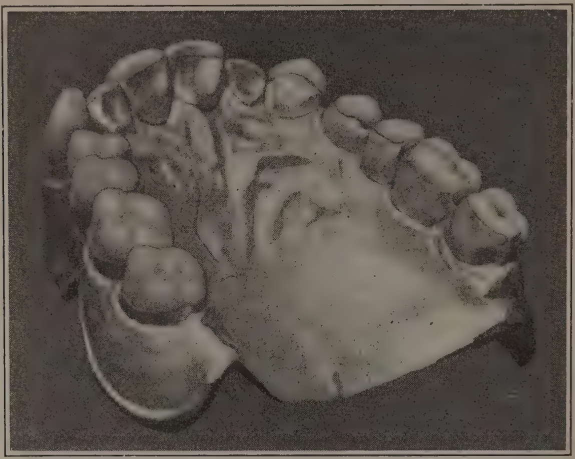

FIG. 352.—Tin-foil applied to lingual surface. Showing rugæ and carving of the lingual surfaces of the teeth.

This flask is designed to be used with the Donham clamp. (See Fig. 373.)

The maxillary surface of the case, having been cleansed of wax, is filled with artificial stone, which forms a cast upon which the denture is vulcanized. This vulcanization cast should be not less than ¼ inch thick at the thinnest portion of the vault, and should not overlap the tin facing. In one hour this cast will be suffici-

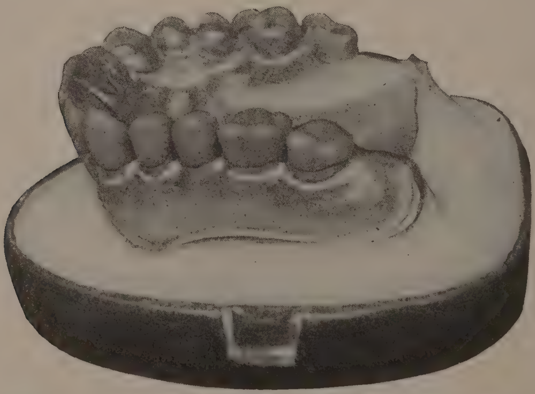

FIG. 353.—Cast and denture invested in Wilson flask.

ently hard to place in the first section of the flask with regular dental plaster (see Fig. 353). The peripheral string will be a great aid in outlining the denture in the investment plaster. After the plaster has set, it is coated with a separating fluid, and then held under the faucet so as to moisten the tin-foil and thus facilitate the flowing of plaster into the interproximal spaces at the time the flasking is completed. The flask should stand about twenty-five minutes and then be placed over the stove in a stew-pan of cold water to be heated up as before described.

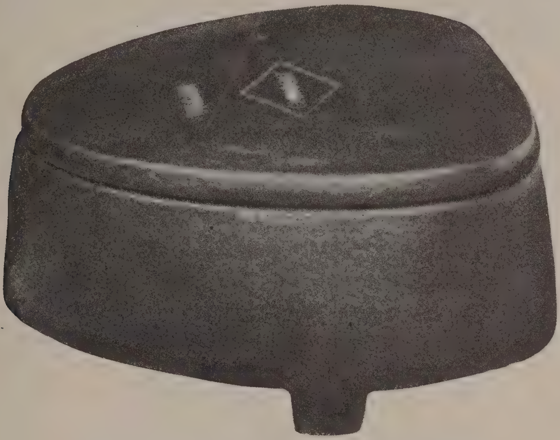

Fig. 354.—Counter portion of Wilson flask.

Separating the Flask.—When the heat of the water indicates the time of opening, the flask is grasped with a cloth-holder in the left hand and separated by the point of a knife blade or wax spatula inserted at the heel of the flask. The instrument should be guarded by the thumb and finger of the right hand to avoid the possibility of marring the case. The strings and as much of the wax as possible are removed with the spatula, when the remainder is removed by pouring boiling water upon it; then with a cloth the vulcanite base-plate and tin lining are wiped dry. The vulcanite base-plate is further cleaned with a cloth saturated with chloroform (Figs. 355 and 356). The excess space is cut with small gates (see Fig. 356), and the separated flask is placed over the sheet iron to warm as previously described. The small gates leading to the excess space should be used only with a bolted flask. A spring controlled flask should have the excess space but no small gates leading to it.

Packing.—Sufficient granular gum or pink rubber is cut into strips to form a layer of one thickness over the tinned surface. First pack a narrow strip of red rubber about the pins (Fig. 357, *C*), and small square or triangular pieces of granular gum between the cervical portions of the teeth. The strips of granular gum are then placed over the labial and buccal surfaces of the matrix with the fingers and wax spatula so that no space remains through which the red rubber can escape. The strip of red rubber about the pins should be pressed down with a wax spatula to form a symmetrical outline. A piece forming half a circle of granular gum is then placed over the anterior

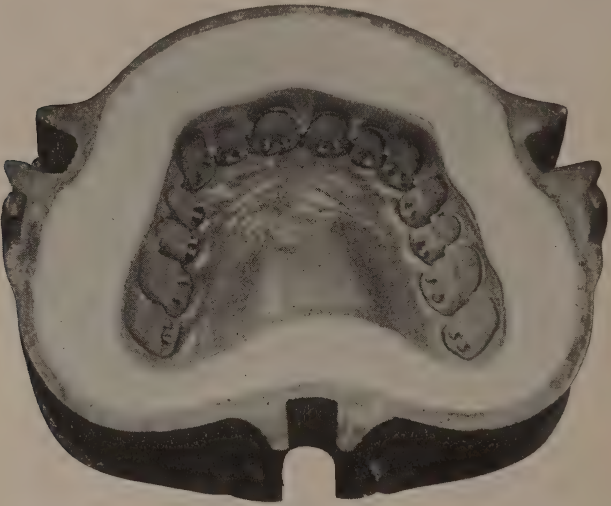

Fig. 355.—Invested case: flask opened and wax removed ready for packing.

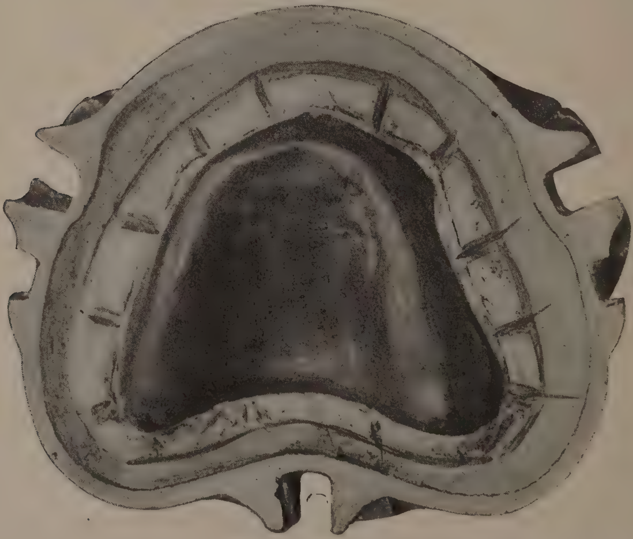

Fig. 356.—Lower portion of flask, showing invested base-plate and outlet vents for the excess of vulcanite.

portion of the lingual surface (Fig. 357, *A*), and with the wax spatula the circular edge is joined to the red rubber about the pins of the teeth. A piece sufficiently large when stretched to half its thickness (Fig. 357, *B*), is then applied over the remaining portion of the lingual surface, and its edges are united to the contiguous rubber. Strips of red rubber are then placed over the teeth to nearly, but not quite, fill the mold. If the restorations are more than 3 mm. thick, they should be filled with pink or white rubber. A separating cloth of closely woven cotton, or the cloth removed from the rubber, after the sizing has been washed out, is saturated with soap and water and placed over the rubber in the mold—when the two sections of the flask are placed together. If the packing has been expeditiously done and the rubber is sufficiently warm, it is placed in the flask press and gentle pressure applied. The flowing of the rubber should be followed every ten seconds with a partial turning of the screw until the flask is closed. The flask is then removed from the press and separated. If there is not an excess of rubber, the cloth will easily separate from the rubber, but should there be strong adhesion; saturation of the cloth with hot water will facilitate its removal. If the plaster has become nearly cold while packing, the flask should be placed in boiling water for three minutes before it is pressed.

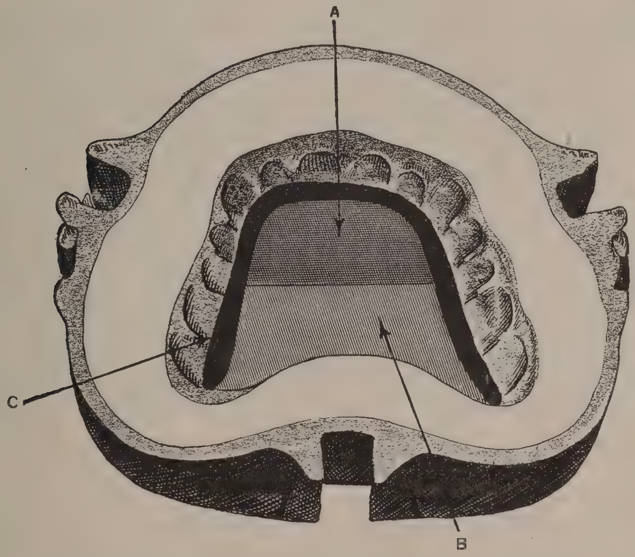

FIG. 357.—Invested case partially packed. A, half circle of granular gum; B, thin granular gum; C, strip of red rubber about the pins.

Vulcanizing.—The case is vulcanized in the same manner as the baseplate. Preference is given to low temperature and long time, 300° F., for three hours from the time of applying the heat. It should not be taken from the flask until it is cold.

Finishing.—After washing to remove the loose plaster, the tin can be easily stripped off, and the excess vulcanite filed from the periphery of the denture. A sharp chisel should be used to trim about the labial and buccal surfaces of the teeth, but the lingual surface should be trimmed with a scraper. The file marks about the periphery of the plate should be removed with fine sandpaper. The labial, buccal and lingual surfaces are buffed with felt wheels and cones carrying pulverized pumice and water. The spaces between the teeth are best reached with a stiff bristle brush-wheel, using wet pumice. All the surfaces including the maxillary, are glossed by using a rapidly revolving soft brush-wheel and whiting wet with alcohol or water.

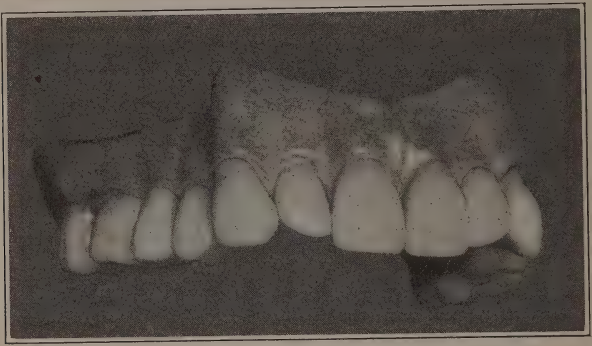

Fig. 358.—Completed denture for case A.

Case A.—Figs. 348, 349, 350, 351, 352, 358. Constructed for a lady about fifty-five years of age, and of square type. Teeth, S. S. W. natural forms, mold number 227, shade number 47. The illustration will show that nearly all the teeth were ground for the purpose of occlusion or to represent age, and the laterals to represent a personal peculiarity. When the finished denture was placed in the mouth it was observed that the central incisors and canines were too much curved in the long axes of the teeth. The labial surfaces of these teeth were ground to give them the square angular form indicative of the square type, thus completing the harmony in form. These ground surfaces were then given a dull polish as described in the paragraph "Grinding and Polishing" under the heading—"General Technic Instruction." These photographs were made before the grinding of the labial surfaces. Attention is called to the canine eminences and the incisive and canine fossæ.

Case B.—Patient about forty-five years of age, of ovoid type. The patient had worn artificial dentures for fifteen years. Teeth used, S. S. W. natural forms, mold number 202, shade number 40. Attention is called to the extensive contours; also the general rounded outline indicative of the type (Figs. 359 to 367 inclusive).

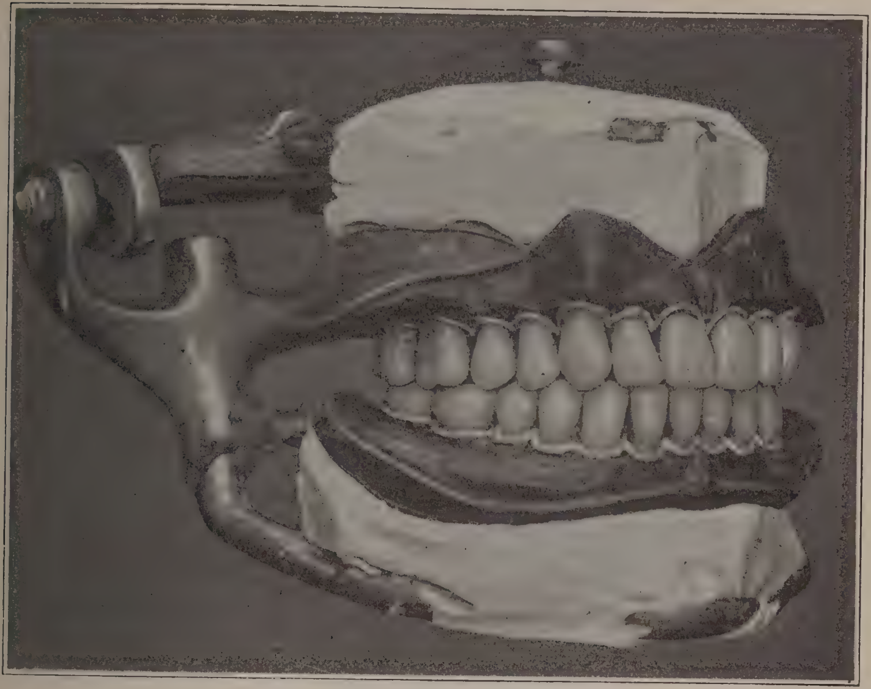

Fig. 359.—Full upper and lower cases waxed up, showing large contours and method of using waxed string.

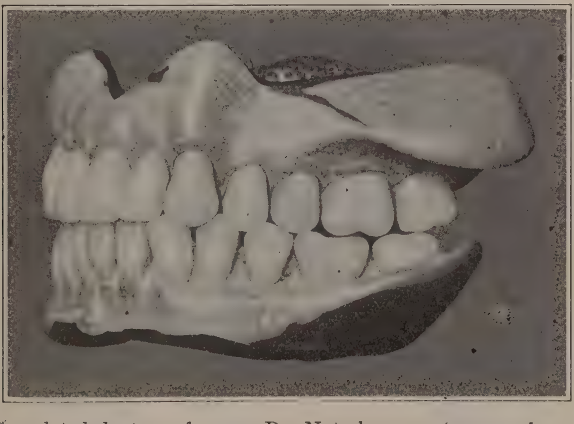

Fig. 360.—Completed dentures for case B. Note large contours on buccal surface of upper plate.

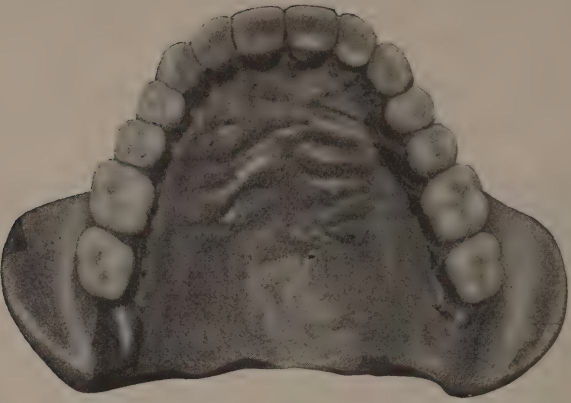

Fig. 361.—Lingual surface of upper denture shown in Fig. 360.

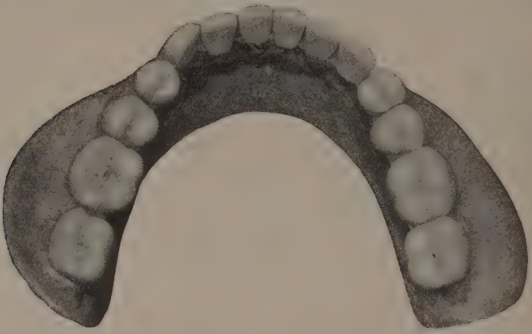

Fig. 362.—Occlusal surface of lower denture shown in Fig. 360.

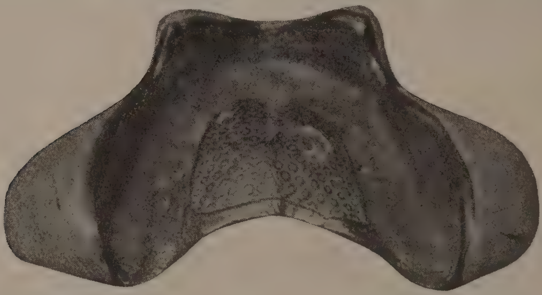

Fig. 363.—Maxillary surface of denture shown in Fig. 360.

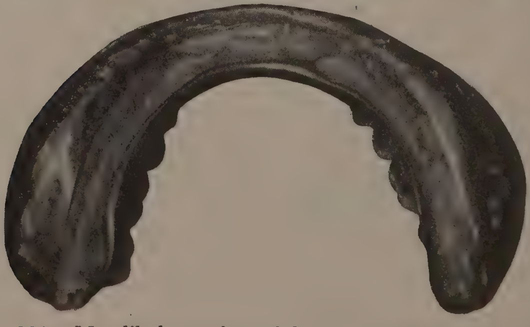

Fig. 364.—Mandibular surface of denture as shown in Fig. 360.

Case C.—Lady thirty to thirty-five years of age. Marked tapering type. Teeth S. S. W. natural forms, mold number 215, shade number 31 (Fig. 368).

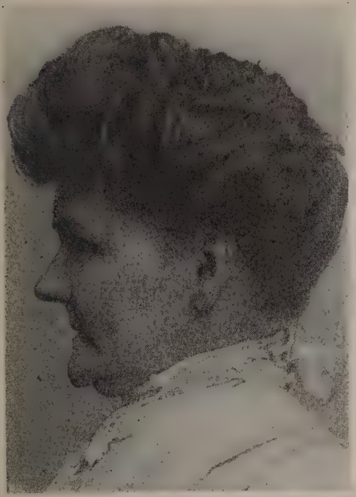

Fig. 365.—Profile view of patient described as case B. Before the insertion of the denture.

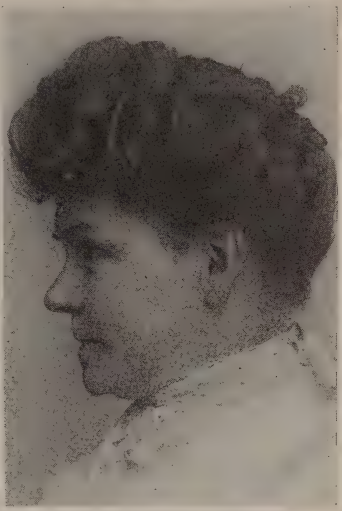

Fig. 366.—Profile view of patient with denture in place.

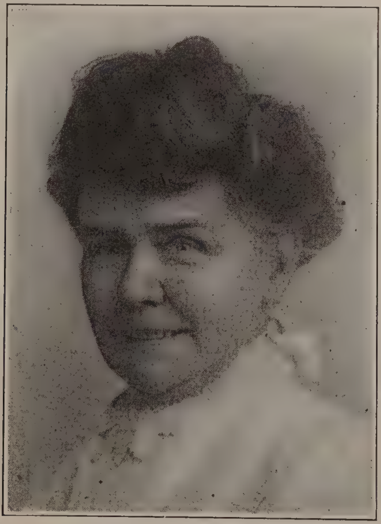

Fig. 367.—Three-quarter view of patient with denture in place.

Case D.—Lady about fifty years of age, ovoid type. Teeth S. S. W. natural forms, mold number 223, shade number 40. Gum restoration about the thickness of a sheet of base-plate wax. Only suitable for construction by single vulcanization method (Fig. 369).

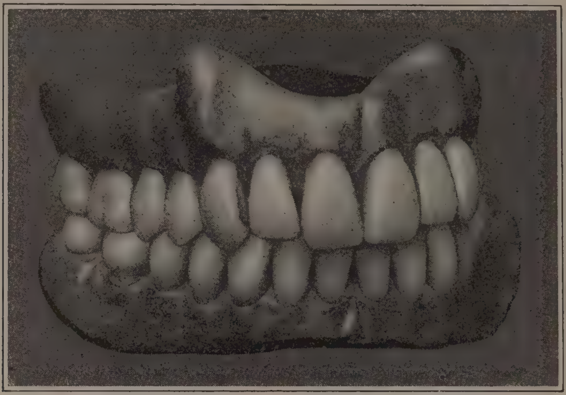

Fig. 368.—Completed denture for case C.

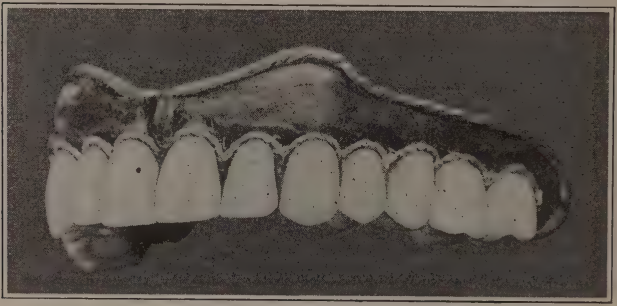

Fig. 369.—Denture for case D.

FULL UPPER: SINGLE VULCANIZATION METHOD.

A plaster compound cast is made from the impression, upon which is formed a base-plate of paraffin and wax, modeling compound, or any of the hard gum base-plate materials upon the market. The wax is arranged in the same manner as upon the vulcanite base-plate for obtaining the occlusion models. (Chapter V.)

The cast and occlusion models are attached to the articulator. The teeth are arranged, the gum contoured, and the case tried in the mouth. It is obvious that it will be more difficult to prove the occlusion, contour and expression, because of the imperfectly fitting trial plate. The denture is then cleansed of the secretions of the mouth, dried, and the tin-foil adjusted upon the wax. With a hot spatula and a little wax the case is sealed to the cast. The cast is then well saturated with water, when it can be easily removed from the articulator by inserting the end of a knife blade between the cast and attaching plaster. It is then ready for flasking, as in the previous case.

The labial and buccal surfaces are packed with granular gum or pink rubber as in the other method, but the lingual surface is packed entirely with base rubber. Care should be exercised to properly distribute the rubber about the mold and to use no excess for the first closing of the flask. After removing the separating cloth, sufficient rubber is added to fill the deficiencies and give a slight excess when the flask is closed. It is then vulcanized and finished as in the former case.

FULL UPPER: SINGLE VULCANIZATION SUB-METHOD.

The procedure is the same as the preceding method, up to the preparing of the case for flasking. The strings and tin-foil are not applied, but the wax form is nicely smoothed in the Bunsen flame or by use of soft cloth or cotton and some solvent of wax—chloroform is the least objectionable. The case is then flasked and the rubber packed against all portions of the plaster, except the cast, which should always be finished either with the thin tin and soap, or silex. Owing to the rough surface produced by contact with the plaster, it will be necessary to file, scrape and sandpaper the entire labial, buccal and lingual surfaces before they are ready for polishing, thus more than offsetting the time saved by not applying the strings and heavy foil. The surface produced is not as hard and dense as that obtained from contact with the metal.

FULL LOWER: DOUBLE VULCANIZATION METHOD.

The only difference in method of constructing the lower and upper dentures is in the application of the peripheral string, which in the lower should completely encircle the base-plate; while in the upper the distal edge is not outlined from heel to heel.

FULL LOWER: SINGLE VULCANIZATION METHOD.

The one detail in the construction of this lower denture, which differs from that of the upper one, is the necessity for adding a 16-gauge soft iron wire stiffener over the wax base-plate, to give rigidity in securing the wax occlusion models, and later while proving the occlusion by trying in the mouth. The wire is removed from the flask with the wax. See Chapter V for other methods of taking the bite.

PARTIAL CASES.

These are usually made by the single vulcanization or sub-method. They differ from a full case in the manner of flasking and packing, which will be explained under the heading "Flasking."

GENERAL TECHNIC INSTRUCTIONS.

Flasking.—*Rule I.*—All full cases and partials with gum restorations should be flasked so as to separate at the periphery of the wax. The Wilson or Star flask is best adapted to this class of work. If the Star flask is used, the case must first be embedded in the narrow rim portion of the flask.

Rule II.—All partial dentures without gum restorations, and most repairs must be so imbedded in the first section of the flask that the teeth are held securely in apposition with the cast when the flask is opened. The Star flask, using the wide rim first, or any of the various forms of flasks of the Whitney type, is best for these cases. Under this rule the cast and denture are imbedded in the encasing plaster of the first section of the flask, the wax only being exposed. The plaster in the first section must be so shaped that the two portions of the flask can be easily separated.

In connection with this rule, attention is called to a class of repair cases that perplex the novice; namely, those having an extensive fracture upon both the lingual and buccal or labial surfaces. This difficulty in flasking is overcome by attaching one or more shafts of wax, one-fourth inch in diameter, at suitable locations over the fracture upon the labial or buccal surface. The shaft of wax must be sufficiently long to extend through the encasing plaster. When the plaster has hardened, a portion of the wax shaft and the surrounding plaster is cut away to form a cone-shaped depression, which will be filled in with the plaster in the top section of the flask. These wax shafts will form openings through which the rubber can be packed, and which are to be filled with rubber. After vulcanization, the shaft of rubber may be removed with a mechanical saw. (See Figs. 409 and 410.)

The salts $NaCl$ and K_2SO_4 should never be used to hasten the setting of the plaster in the flask, as they weaken it and make the warping of the plate during the closure of the flask and vulcanization more likely.

Packing.—When the case is prepared for packing as described in the double vulcanization process, some operators prefer placing the cold rubber in the flask, because it is firmer and easier to handle, and will soon become warm and pliable from the heat of the flask; other operators prefer warming the rubber as well as the flask, and it is better for all students to do so until they have gained dexterity and confidence in their ability to quickly pack the case before the flask becomes too cold.

A convenient way to warm the rubber is to heat in hot water a piece of soap-stone (a small-sized foot warmer), and after the rubber is cut into suitable strips, it is placed upon the stone. By this means the stone does not become too hot, and holds the heat well. Another device is a porcelain dish upon which the rubber is placed and is kept warm by placing the dish over a receptacle containing hot water. An electric warming oven serves this purpose excellently (see Fig. 380). It is very essential in packing a case that the rubber shall be evenly distributed through the mold so that in closing the flask there will be no undue pressure at any point, thus avoiding a warped denture or elongated teeth.

Vulcanizing.—For convenience, cleanliness and uniformity of results, dental vulcanization is accomplished in a specially constructed machine, called a vulcanizer (see Figs. 381–391), which is a steam-tight boiler. The operation can be accomplished in a sand, glycerin or oil bath, but this is not desirable for obvious reasons. The time of vulcanizing will be influenced by both temperature and the surrounding medium. Vulcanization begins at 248° F., but at that temperature it would require many hours; at 280° F., it will require five and a half hours; at 300° F., two and a half hours; and at 320° F., fifty minutes. The medium surrounding the flask in the vulcanizer must be either water, steam or air. The time required to produce the same result will be in inverse ratio to the conducting power of the medium; water being the best conductor of heat will require the least time, steam second, and air being the poorest conductor, will require the longest time. However, owing to the fact that water is more detrimental to the physical properties of plaster than steam the best results are obtained by elevating the flask above the water in the vulcanizer. Two to 5 fluidounces of water is sufficient for a two or three flask vulcanizer. It is always best to permit the vulcanizer to stand until it is cold before opening, but when it is necessary to expedite matters, the steam may be blown off, the vulcanizer opened, and the flask be set in a pan of cold water. This last procedure would be condemned by some, but owing to the poor conducting and radiating property of plaster, it is doubtful if this method of cooling ever accounts for fractured teeth. Under no condition, however, should the flask be opened until the plaster in the center of the flask is cooled to blood heat, which will be sometime after the flask is cold if placed in water.

Finishing.—The filing is done with a rather coarse file especially made for this work (see Fig. 394). A 7- or 8-inch half-round file having an oval and a flat side, a coarse and a fine end, is a very desirable instrument. The cutting is done with a push stroke. A round or rat-tail file is also very useful. For scraping and trimming the plate, short shank Kingsley scrapers numbers 1 and 5, and an Ivory scraper number 9, and a Wilson or a Spaulding chisel, make a very complete equipment (see Figs. 395–398). These instruments should be kept very sharp by grinding and honing. The sandpapering is done with a 2 inch square piece of number ½ or 1, followed with number 00 paper. The paper is cut into squares by placing the sand side down over a crevice and cutting with a knife. Various substances are used for buffing wheels and cones, but felt has proved the most satisfactory. The wheels have either a square or a knife-edge. The knife-edge soon becomes so blunt that it fails to do the work for which it was designed. This difficulty can be overcome by using a worn-out half-round file ground to a sharp edge, held by an end grasped in each hand, when the felt wheel can be quickly and safely turned to shape. The felt carries the abradant, of which pumice is the best, and must be kept well moistened; otherwise the vulcanite will be heated and possibly warped. The wheel should be run at a moderate speed, and the hands holding the work firmly against the felt carrier must be kept in constant motion, so that symmetrically curved surfaces may be formed, and not ridges and grooves, as the result of too long continued contact at any one place. A large and small size of each of the forms of the buffers used should be provided. A stiff converging bristle brush-wheel, in which the bristles have been worn or cut away one-half, will be more effective for buffing between the teeth. Striking the work against the moderately revolving brush will cause the bristles to reach the innermost spaces. As before stated, the glossing is done by using a rapidly revolving soft bristle brush-wheel and whiting wet with alcohol or water. Very good results can be obtained by rubbing the surface of the vulcanite in the hand with dry plaster of Paris.

Cutting excess vulcanite from the proximal spaces between the teeth and finishing this portion of the denture, can best be accomplished by sharpening the shank of a large or medium size worn-out dental bur to a three-sided point and, while revolving rapidly in the dental engine, working it into these spaces.

Grinding and Polishing the Teeth.—It will often be necessary to grind the exposed surfaces of the teeth, which should again be polished. The abraded surface should be well sandpapered. The paper is held against the ball of the thumb which will conform the paper to the surfaces of the teeth and greatly facilitate the removal of the facets formed by the grind-stone. It is then buffed with the felt wheel and pumice; or a specially prepared rubber wheel can be obtained for this work.

Notching the Cervical End of the Teeth.—In some cases where there is gum restoration, it is desirable not to have the rubber overlap the cervical end of a tooth, and in these cases cruciform notches should be cut in the cervical end with a small knife-edged stone, into which the rubber will flow and harden and aid in supporting the tooth.

DR. GEORGE B. SNOW'S METHOD.[1]

The following table showing Dr. Snow's experimental work followed by his explanation and conclusions are very instructive and give a scientific and logical reason for his Compensating Vulcanizer. (See Fig. 389 and method for using it.)

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[1] Dental Cosmos, September, 1918.

TABLE SHOWING THE BEHAVIOR OF DIFFERENT RUBBER COMPOUNDS IN VULCANIZING

	Weight unvulcanized.	Weight in water, unvulcanized.	Displacement in grams and cc.	Sp. gr. unvul.	Weight vulcanized.	Weight in water, vulcanized.	Displacement in grams and cc.	Sp. gr. vul.	Shrinkage, cc.	Percentage of shrinkage.	Overflow, weight.	Overflow, bulk, cc.	Deficiency in bulk, cc.	Percentage of deficiency; bulk.
McCormick	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Lt. Pink	28.247	17.872	10.375	2.723	28.240	18.197	10.043	2.812	.332	.032	.865	.308	.640	.062
Ord. Black	11.380	1.155	10.225	1.113	11.393	1.678	9.715	1.173	.510	.050	.625	.533	1.043	.102
Maroon	17.235	6.965	10.270	1.678	17.263	7.502	9.761	1.768	.509	.049	.891	.503	1.012	.099
Lt. Red	17.321	7.009	10.312	1.680	17.347	7.478	9.869	1.758	.443	.042	.876	.498	.941	.091
S. S. White														
Maroon	18.165	7.912	10.253	1.771	18.18	8.38	9.8	1.845	.453	.044	.708	.384	.837	.082
Gold Base	16.417	6.091	10.326	1.589	16.437	6.539	9.898	1.66	.428	.041	.633	.381	.809	.078
No. 1 Red	21.595	11.302	10.293	2.098	21.602	11.725	9.877	2.187	.416	.040	1.036	.474	.890	.086
Doherty														
Maroon	15.821	5.526	10.295	1.538	15.837	6.040	9.797	1.616	.498	.048	.924	.572	1.070	.104
No. 1 Red	17.368	7.162	10.206	1.702	17.379	7.627	9.752	1.782	.454	.044	.802	.450	.904	.089
Samson	14.545	4.34	10.205	1.425	14.569	4.864	9.705	1.501	.500	.049	.792	.528	1.028	.101
Traun														
Gold Dust	11.498	1.272	10.226	1.124	11.517	1.764	9.753	1.181	.473	.046	.582	.493	.966	.094
Ash's														
Dk. Elstc.	13.200	2.730	10.470	1.261	13.220	3.547	9.673	1.366	.797	.076	.579	.424	1.221	.117

Explanations.—All weights in this table are in grams. All bulks in cubic centimeters.

All samples were vulcanized at 75 pounds by the steam gauge, it being the same as 300° F., by the Mercury Bath Thermometer, or 320° actual temperature.

Columns 3 and 7 show the weight and also the bulk of water equivalent to the respective samples; as a cubic centimeter of water weighs one gram.

All the vulcanizing was done in the same brass mold, which was closed by bolts without springs, and had a gateway leading to an overflow chamber, which received the rubber expelled from the mold as it was heated from 212° F., to the vulcanizing point. The capacity of mold at 70° F., 10.710 cc.; at 212°, 10.759 cc.; at 320° (75 pounds' pressure), 10.796 cc.

The discrepancies between columns 1 and 5 are due to the absorption of a small quantity of water by the rubber when vulcanizing; showing that vulcanite is slightly porous. The amount of water absorbed is about half a drop for a sheet of rubber. Rubber compound does not lose weight by vulcanizing.[1]

Column 11 denotes the weight of rubber expelled from the mold as the sample is heated from 212° to the vulcanizing point. Column 12 shows the bulk of the same.

In column 13, the shrinkage, shown in column 9, which is the difference between columns 3 and 7, is added to the overflow, column 12, and shows the total amount of deficiency of vulcanite in the mold when the vulcanizing process was completed. Column 14 gives the percentage of this deficiency. It will be noted that the deficiency is greater in the dark colored rubbers and less in the lighter colored ones, the light rubbers containing more foreign matter in their composition.

Conclusions.—If the flask is bolted and gateways provided for the free escape of the rubber as it is heated, the deficiencies shown in columns 13 and 14 are inevitable, and the denture will always be defective.

If spring pressure is applied to close the flask, and the rubber is confined so that none of it can escape unless the parts of the flask are separated by its expansion, the deficiency will be less than that shown in columns 13 and 14; the amount depending upon the average thickness of rubber in the case.

To produce the best results, spring pressure must be used to close the flask, the mold must contain an excess of from 3 to 5 per cent. of rubber when vulcanizing commences, and the flask must, therefore, not be entirely closed at this time. Its closing must be effected gradually by spring pressure and after the vulcanizing process has progressed far enough to cause a partial shrinkage of the rubber. For vulcanizers of the ordinary type this may be accomplished by two vulcanizations.

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[1] More recent investigation, I believe, will show this discrepancy to be due to unequal compression in flask closing rather than porosity.

INSTRUMENTS AND APPLIANCES USED IN VULCANITE WORK.

Wax Spatulas.—The instruments shown in Figs. 370 and 371, are some very useful forms. The Evans' numbers 2 and 3 and one of the others, will meet every requirement.

Flasks.—There are a great many varieties of vulcanite flasks upon the market. They are made of iron and brass. Iron has the greater affinity for oxygen and sulphur in vulcanizing, consequently not so easily cleaned, but they are more rigid than the brass and not liable to be warped out of shape. The brass flasks are the more easily cleaned. Each time they are used, they should be thoroughly cleaned with a stiff brush and Sapolio.

The Star flask is one of the oldest forms, and being reversible, is probably adapted to more cases than any other (Fig. 372). The Wilson flask is characterized by a very narrow rim upon the lower section, with a correspondingly wide rim in the upper section. It is designed to be used for full cases only and with the Donham spring clamp (Fig. 373). The Donham spring clamp is shown in Fig. 373. The Whitney flask is very much used. There are two sizes, the larger being five-sixteenths of an inch deeper than the smaller. Fig. 374 shows the regular size with springs upon the bolts to aid in closing the flask.

The box flask is designed for interdental splints and any extra large pieces of vulcanite. It is made in two sizes, one as large as can be used in a two-flask vulcanizer and the other for the three-flask vulcanizer (Fig. 375).

The Edson flask is especially designed for the Edson vulcanizer, and may be used for both vulcanite and celluloid (Fig. 376).

Volute-spring.—The volute-spring is a flat steel bar coiled in a spiral conical form and compressible in the direction of its axis. It will produce approximately 100 pounds' pressure with each $\frac{1}{8}$ inch closure, and occupies the space of one flask. The large end of the spring is placed against the flask so that the pressure of the spring is upon the periphery of the flask, thus properly distributing the pressure. Ordinarily the spring should be closed $\frac{1}{4}$ inch, which will place the rubber under approximately 200 pounds' pressure; however, if the flask is not perfectly closed in the flask press an additional closure of the volute-spring should be made to equal the space the flask is to be closed. The spring acts not only as a follow-up spring but as a regulator for the expansion of thick masses of rubber that may be required in large restorations.

The spring, properly placed, is shown in Fig. 373.

Flask Presses.—The flask press is an indispensable appliance in a well-equipped laboratory (Figs. 377, 378 and 379), and yet probably

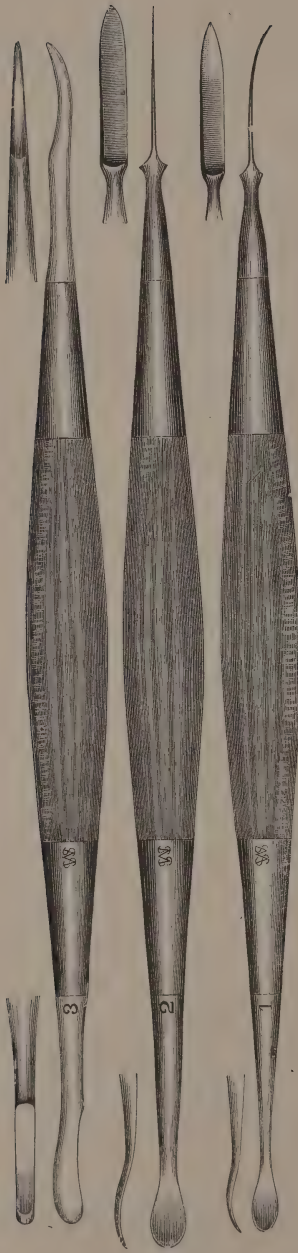

FIG. 370.—Evans' carving tools.

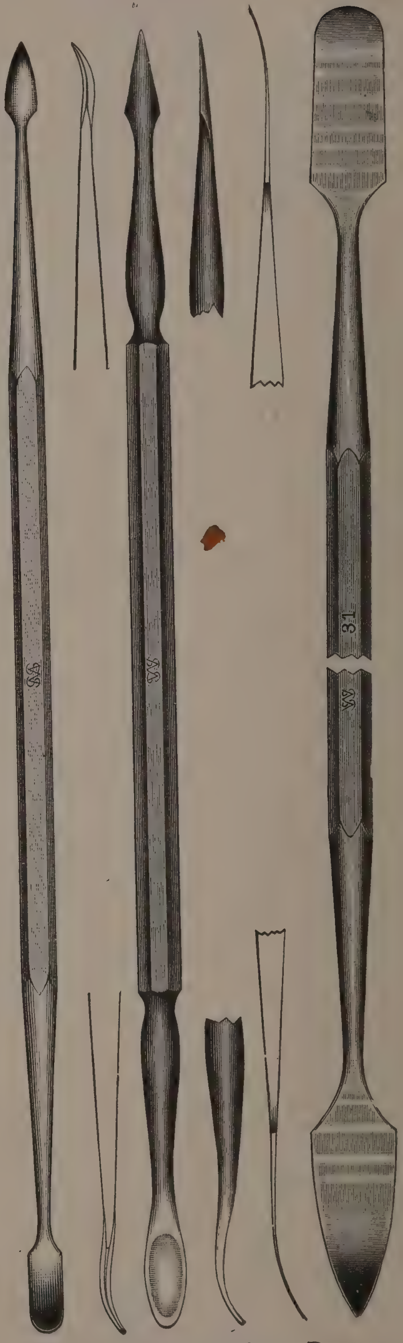

FIG. 371.—Wax spatulas: Dorance, Burchard, Gritman.

its improper use has caused more misfit vulcanite dentures than all other causes. When the principles involved in the flask press and its use are understood, there should be no trouble in handling it. All plasters expand and are compressible, some excessively so. French's regular dental plaster is the best and most commonly used by the profession, so these statements are in connection with this plaster. A molar tooth $\frac{1}{2}$ inch in diameter under 1000 pounds' pressure would be driven into well set plaster $\frac{1}{20}$ inch. Rubber when cold is very tenacious and will resist a very heavy pressure for a short time, but

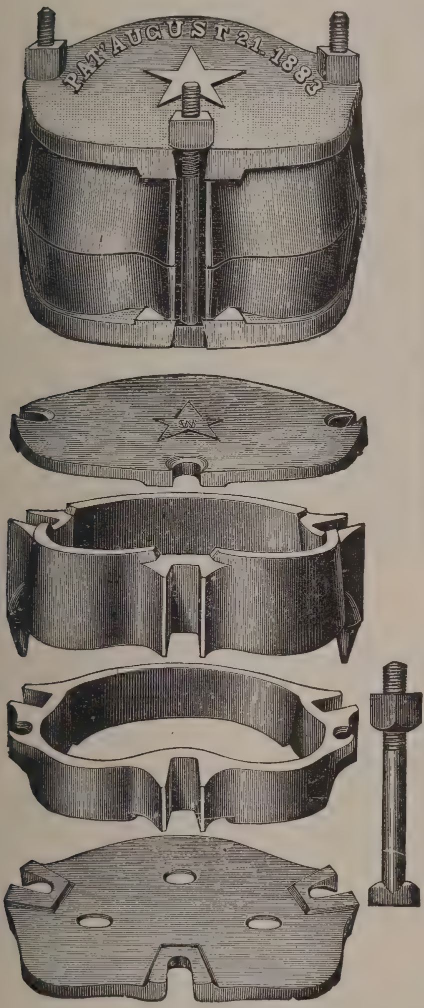

FIG. 372.—Star flask.

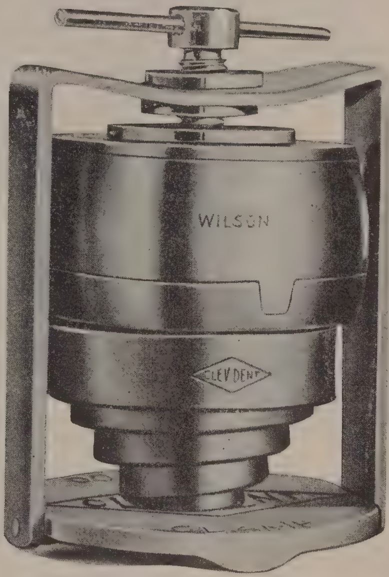

FIG. 373.—Donham clamp, Wilson flask and volute-spring.

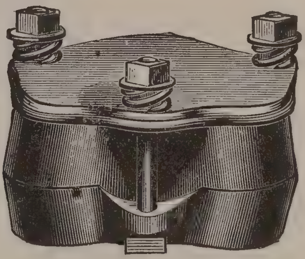

FIG. 374.—Whitney flask.

will gradually yield. Plaster compresses to its full extent in a very few seconds. It is easy to comprehend that if an excess of rubber is placed over the teeth upon one side, and heavy pressure is applied, that the teeth will be driven into the plaster encasement and consequently the teeth upon that side of the denture will be too long. It can also be comprehended that if the cast is formed of regular plaster, and excessive rubber and pressure be applied to the vault of the cast, that it will be pressed upward and the plate warped.

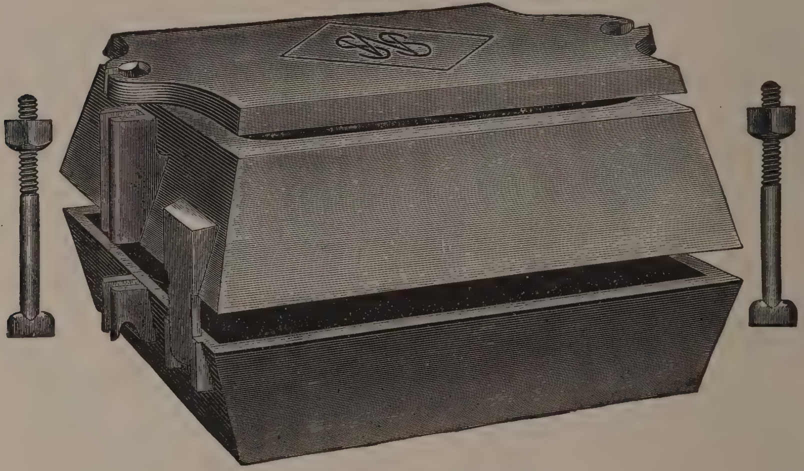

Fig. 375.—Box flask.

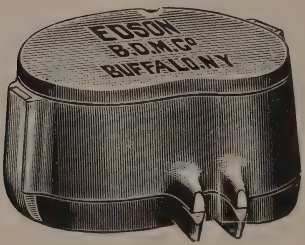

Fig. 376.—Edson flask.

We shall now consider the power of the press. The screw is a combination of the lever and wedge, and its power is calculated by multiplying the circumference described by the lever by the pitch of the screw. The Buffalo Dental Manufacturing Co. No. 2 press, Fig. 378, has a handle 8 inches long, hence describes a circumference of 25 plus inches. There are ten threads to the inch, hence a pitch of $\frac{1}{10}$ inch. An allowance must be made for friction in the screw, but one fifth will be very liberal, when we shall have for every pound of force applied at the end of the handle, 200 pounds' pressure under the screw

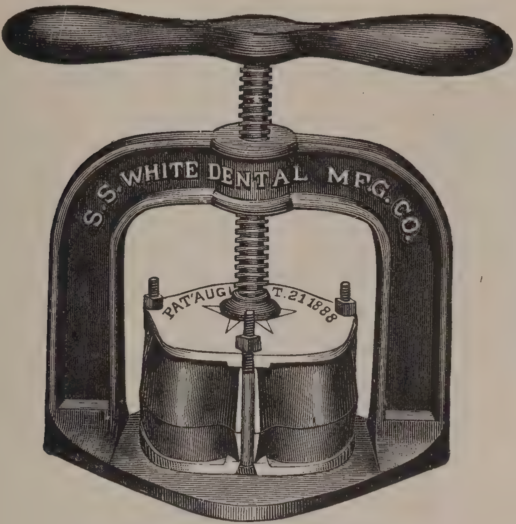
S.S. WHITE DENTAL MFG. CO.
PAT'AUG
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FIG. 377.—Press with volute-spring.

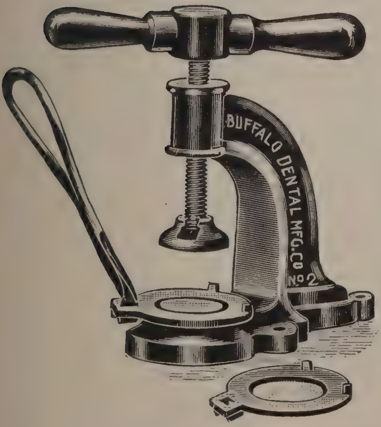


FIG. 378.—Buffalo No. 2 press.

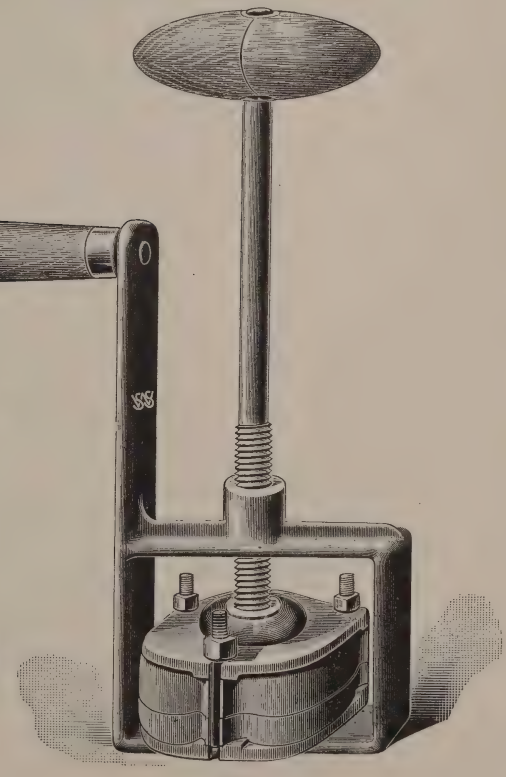


FIG. 379.—Dr. E. Wilson's press.

or 1 ton for every 10 pounds of force. If the force is applied as the hand ordinarily grasps the handle, it will produce one-half as much pressure, or 1 ton for every 20 pounds of force. It is now easily understood why plates are warped, and these heavy malleable iron presses are sometimes broken. The student should now return to the Double Vulcanization Process, and read again how to use the press.

The volute-spring, in the press of the Cleveland Dental Manufacturing Co., helps to overcome the danger of the rigid press. The spring supplies a follow up pressure upon the flowing rubber (Fig. 373). This press is so compact that it and the flask being compressed may be placed in the stew-pan of boiling water. The flask should always be placed, in any press, with the cast side down so as to be supported by the broad flat base of the press. Many unnecessary accidents have occurred by placing the cast side next to the screw.

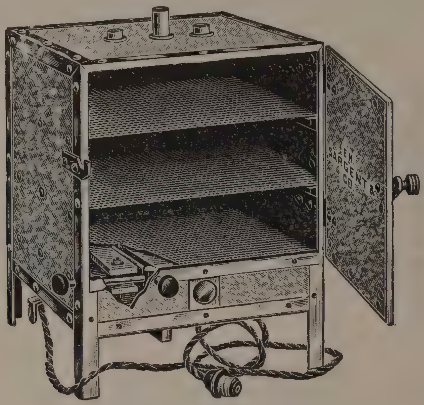
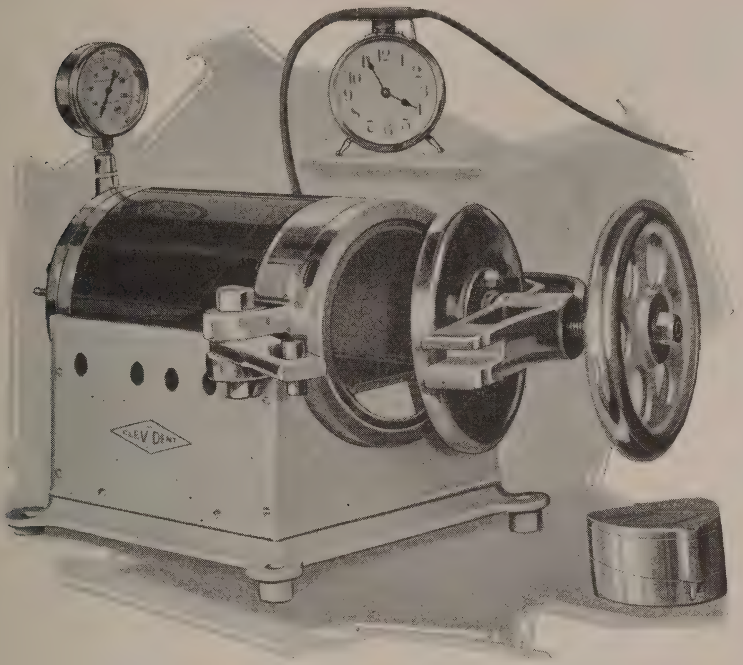

E. H. SARGENT & CO. CHICAGO

Fig. 380.—Sargent's electric oven.

Flask, Wax, Rubber Warming Oven.—Fig. 380 shows a convenient arrangement for the purpose. It is a low heat electric oven put upon the market by E. H. Sargent & Co., Chicago, Ill. It can be regulated and set for any temperature up to its maximum (400° F.). With the heat regulated to 220° F., it is especially convenient for warming the flask, for removing the wax and for packing the rubber. At the indicated temperature there is almost no danger of overheating. The thermometer is inserted in the middle opening of the top of oven. However, an Interval Timer should be used in connection with the oven, thus relieving the mind of the operator.

Vulcanizers.—There are in use at the present time many forms of vulcanizers. It would be unnecessary to enumerate them all. These descriptions will, therefore, be confined to some of the best and simplest examples of the somewhat extensive list.

The Furnas Vulcanizer.—This vulcanizer is manufactured by the Cleveland Dental Manufacturing Company. It is somewhat different



Furnas vulcanizer.

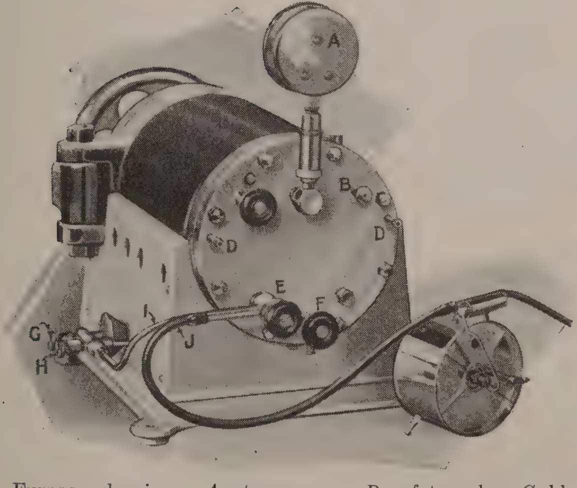


Fig. 381.—Furnas vulcanizer. *A*, steam gauge; *B*, safety valve; *C*, blow-off valve; *D*, water connections for circulating cold water through jacket; *E*, thermostat regulator; *F*, drain valve for draining water from the boiler after vulcanization; *G* and *H* valves for gas burner and pilot light; *I*, permanent metal connection from the gas regulator to the burner; *J*, hose connection to the time attachment or gas supply.

in type, yet similar in principle. The flask rests on a tray over the water, making it impossible to vulcanize in other than an atmosphere of steam. The pot is half surrounded by a water jacket which acts as an insulator during vulcanization and into which cold water may be turned after vulcanization to aid in cooling. This method of cooling will not permit the temperature to be reduced sufficiently rapidly to cause warping or "graining" of the vulcanite.

The regulator may be set at any pressure from 2 to 85 pounds. The lower pressure may be used when the operator wishes to use the vulcanizer as an "autoclave sterilizer." No bolts or wrenches are required in operation (Fig. 381).

Electric Vulcanizer.—The Lewis automatic electric vulcanizer comprises the Lewis cross-bar vulcanizer fitted with an electric heating apparatus, an electric heat controller and a time cut-off. The electric heater consists of two sections; a jacket unit for holding the vulcanizer, and a base for holding the electrical apparatus, time clock and cut-off mechanism. The base holds the clock with automatic time cut-off which operates a switch (Fig. 382).

Mounted on the vulcanizer cap is a siphon to which is attached the heat controller. This piece of mechanism alternately makes and breaks the contact for controlling the flow of electric current, and is operated by steam pressure generated in the vulcanizer. On top of the controller is a regulating knob with 300 and 320 stamped on its base. These figures represent the degrees of heat which can be obtained by rotating the knob. The clock with time cut-off is mounted on the base by means of parallel rods and is automatically locked in position at the desired time by a catch located at the back of the clock, and pushing into position insures contact with the knock-off pin. This pin when forced inward by the clock makes contact and immediately closes the switch, permitting the current to flow to the heating elements. The electric controller will hold the temperature at the desired point for the entire period of vulcanization with only the slight variation in temperature occasioned by the making and breaking of the contact; a variation too slight to be noticeable on the thermometer.

Edson.—This is an older form of screw-cap vulcanizer. It has a screw press within the boiler, and is suitable for both rubber and celluloid. It is not as easy to handle as the cross-bar variety (Fig. 383).

The Lewis Cross-bar Vulcanizer (Fig. 384) is modern in its essential parts, and embodies many valuable improvements, and is one of the strong, safe, and convenient vulcanizers of the cross-bar pattern.

The boiler is hand-made from copper, rolled expressly for this form of vulcanizer, and is of unusual thickness. The cap is ribbed on the under side to resist any strain which may be put upon it. This cap has but two holes drilled in it, one for the mercury bath, to which the thermometer is attached; the other for the "manifold," which carries the safety-valve, blow-off, gas-regulator, or steam-gage (Fig. 385). The ring surrounding the boiler is of cast steel, and is therefore of ample strength. Beside the lugs for taking the strain off the cross-bar and bolt, it has a dovetailed projection for the insertion of a lifting handle (Fig. 386).

It will be observed that when the cross-bar and cap are removed, there are no swinging bolts or attachments to the pot.

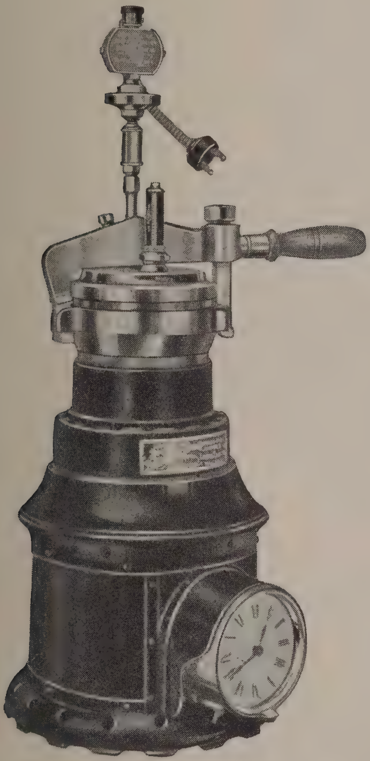


FIG. 382.—Electric vulcanizer.

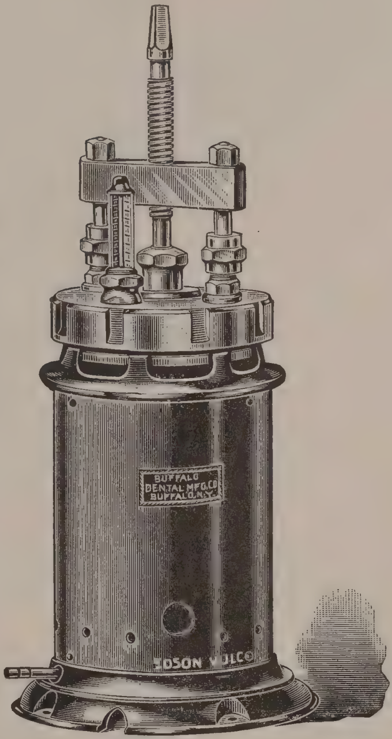


FIG. 383.—Edson vulcanizer.

The cross-bar is of an improved form, and is made of cast steel. One end is at right angles to the main bar, and terminates in projections which catch under the lugs on the ring. Over the projections is a small rib which prevents the bar from dropping out of position. The other end of the cross-bar has an enlarged portion for the reception of the bolt, and is terminated by a handle.

The vulcanizer is closed by one bolt suspended in a slot on the hand-end of the cross-bar. The bolt is squared to prevent rotation, and is surrounded by a spring for the purpose of disengaging it from the lugs when the nut is loosened, and for always retaining the bolt perpendicularly and forcing it in place automatically.

The vulcanizer is opened by loosening the nut on the bolt by means

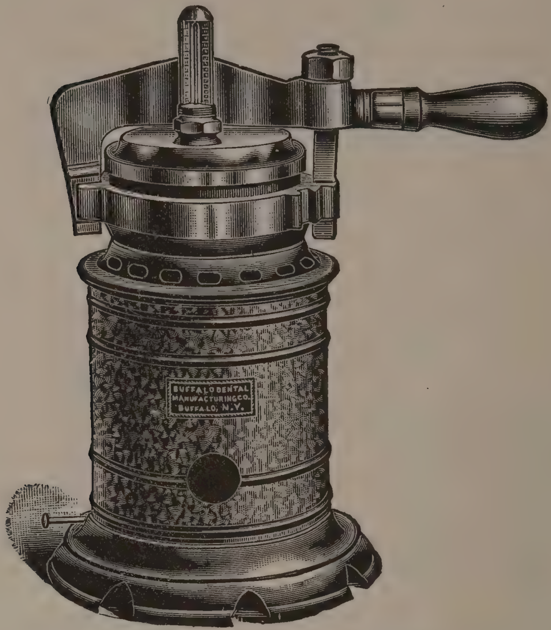

BUFFALO DENTAL
MANUFACTURING CO.
BUFFALO, N.Y.

FIG. 384.—Lewis cross-bar vulcanizer, with gas heating apparatus.

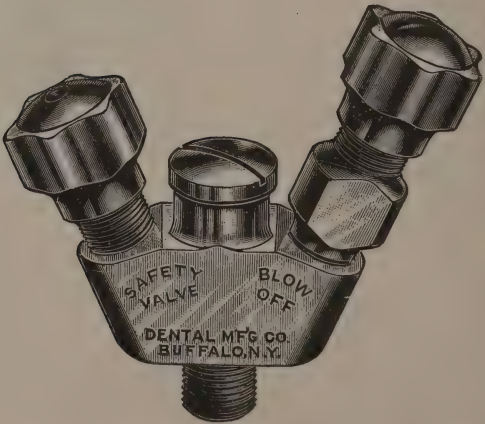

SAFETY VALVE
BLOW OFF
DENTAL MFG CO.
BUFFALO, N.Y.

FIG. 385.—Manifold with safety valve and blow-off.

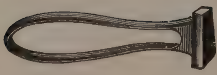


FIG. 386.—Pot-lifter.

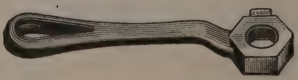


FIG. 387.—Cross-bar wrench.

of the wrench furnished for the purpose (Fig. 387). The bolt will be forced downward through the action of the spring. The handle of the cross-bar is then seized, and with the thumb against the nut it is pressed until the bottom of the bolt is disengaged from the lugs, when the bar may be lifted (Fig. 388).

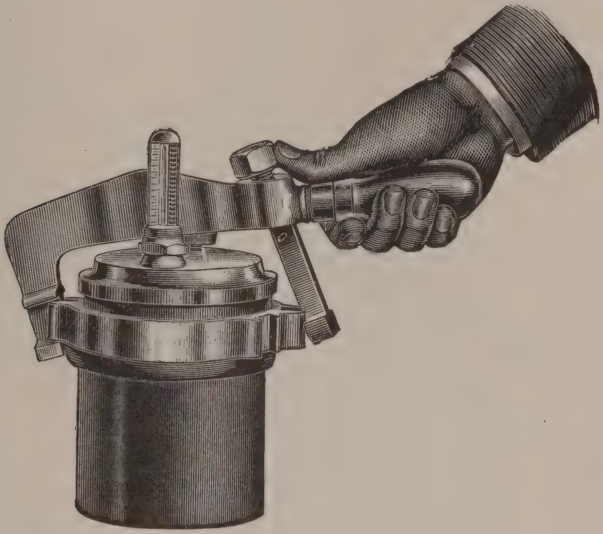


Fig. 388.—Removing Lewis cross-bar from pot.

The Snow Compensating Vulcanizer (Fig. 389) is an improvement upon the Edson in that the cap is bolted on in place of being screwed on; also the stirrup for clamping the flasks to the cap has springs capable of exerting 800 pounds' pressure. The coiled springs are placed in the heads of the yoke, therefore, are removed from the steam and water of the vulcanizer, thus preventing the rapid destruction of the springs which necessarily takes place when inclosed in the vulcanizer. The springs are indexed from 100 to 800 pounds, as shown in Fig. 389. The springs permit the flask to be nearly closed, when the pressure may be removed and the rubber permitted to expand without flowing from the mold. As shrinkage begins with the chemical union of the rubber and sulphur (250° F.), and as the compound gradually toughens, its flowing property gradually decreases; therefore, the author believes that the temperature, as indicated by the thermometer and gas regulator, should not exceed 270° F., or 40 pounds steam pressure, when the final spring pressure of approximately 500 pounds is applied.

The Interval Timer (Fig. 392) is especially useful in heating up the vulcanizer.

The method of vulcanization used by the author at the present time is to warm the flask in the Sargent warming oven (Fig. 380) for removing the wax, and if necessary dash with boiling water containing sal soda. The mold is provided with excess space, but no gateways. The case is dried and warmed in the oven, packed and nearly closed in the flask press, or this closing may be done in the press of the vulcanizer, the vulcanizer closed and the spring pressure removed, the gas regulator (Snow's) is set at 270° F., and the Interval Timer set for one-half hour. When the alarm sounds 500 pounds spring pressure is applied, the gas regulator is then set at 290° F., and the Interval Timer for twenty-five minutes. At the sounding of the alarm the gas regulator is set at 300° F., if the vulcanizer clock was set for three hours, or at 320° F., if the vulcanizer clock was set for two hours. Thus one hour will be consumed in bringing the vulcanizer up to the high temperature, which under the spring control will produce a high grade vulcanization.

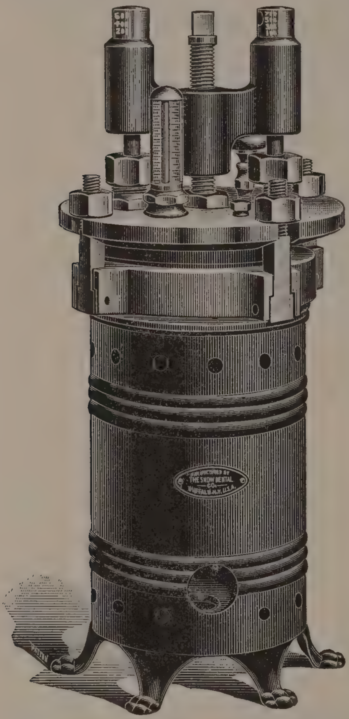


Fig. 389.—Snow's compensating vulcanizer.

The vulcanite must be kept under spring pressure until molecular set is obtained, that is, until the vulcanite is stone cold.

INSTRUCTIONS FOR THE USE OF THE TIME REGULATOR.

"The gas regulator (Fig. 390) is secured to the cap by means of the short iron pipe or coil. This is screwed into a hole drilled through the cap of the vulcanizer, and tapped with a 'one-eighth gas-pipe tap.' If the vulcanizer has a 'Lewis manifold' attached to the cap of the vulcanizer, remove the screw between the blow-off and safety-valve and screw the coil-pipe in its place. After the gas regulator has been properly fitted, place the vulcanizer in the jacket and in the position in which it is to be used. Connections between the time regulator, gas regulator, and gas burner are made by means of rubber tubing. The engraving (Fig. 391) illustrates the correct method of connecting gas and time regulators to vulcanizers. Cut a piece of tubing of sufficient length to reach from the gas-supply tap to the *time regulator*, and connect them; cut off another piece to reach from the time regulator to the *gas regulator*, and attach to the gas regulator by the *upright* or straight nipple on top of the No. 4 Lewis gas regulator; then connect the downward curved tube of the gas regulator to the gas burner under the vulcanizer with another piece of rubber tubing.

"The time regulator is more convenient when placed on a bracket near the gas-supply pipe. It is then out of the way, and not likely to be broken from contact with tools, and can also be used as a timepiece.

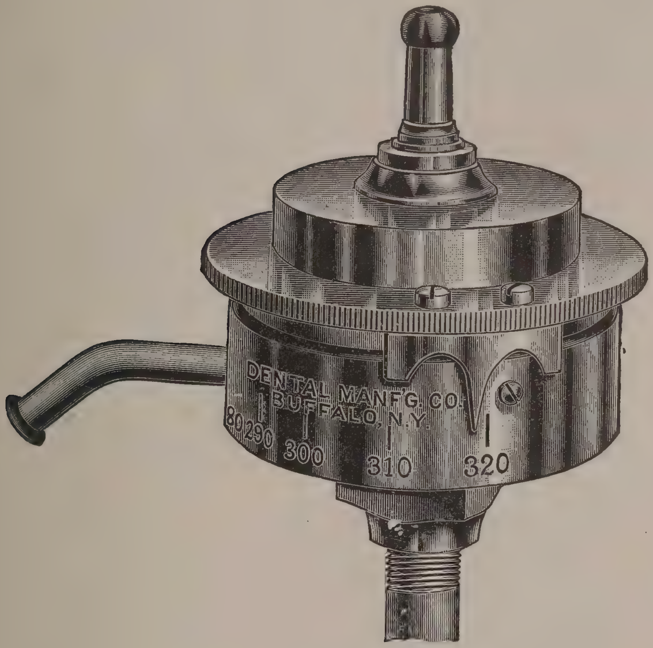


Fig. 390.—Gas regulator.

"**To Set the Time Regulator.**—When the valve lever on top of the time regulator (Fig. 391) is engaged with the screw upon the minute arbor on the back of the clock, the valve is held open for a length of time depending upon whether the lever is engaged with the first, second, or third thread of the screw; and the lever will be cast off, and the valve closed when the minute-hand reaches the figure XII. When the minute-hand is at IX the lever will be cast off at the end of fifteen minutes, if it is engaged with the *first* thread of the screw from the end; an hour and a quarter, if engaged with the *second* thread, and so on. A trial should be made, and the time ascertained which is necessary for heating the vulcanizer to the vulcanizing point, and this time should be added to the proposed time for vulcanizing. We have, therefore, the following:

"Rule.—Turn the minute-hand to as many minutes *before the hour* as the number of odd minutes desired; then put the end of the lever in the threads of the screw upon the minute arbor at the back of the clock. The *first* thread from the end gives the odd minutes to which the clock is set; the *next* and *each* succeeding thread gives a full hour. For example: For an hour and twenty minutes, set the minute-hand at the figure VIII, and engage the lever in the *second* thread from the end of the screw. At the end of that time the lever will disengage and automatically shut off the gas from the vulcanizer. If this were to be an hour longer—*i. e.*, two hours and twenty minutes—the lever should be placed on the third thread of the screw. For three hours, set the minute hand at XII and the lever in the third thread of the screw.

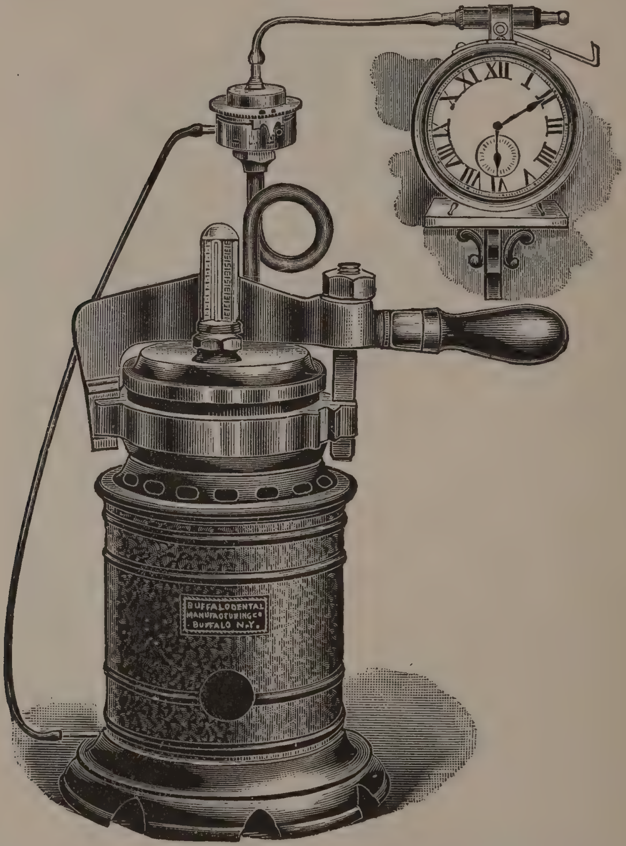

BUFFALO DENTAL MANUFACTURING Co BUFFALO N.Y.

Fig. 391.—No. 4 graduated gas regulator, mounted on a Lewis cross-bar vulcanizer.

"Those who use vulcanizers should be thoroughly informed as to the nature and properties of steam. The fact should be borne in mind that a vulcanizer is subject to the same laws and conditions as a steam boiler, which it is in fact, and, although it is comparatively safe and easily operated, it may, by carelessness or ignorance in its management, become exceedingly dangerous.

"The following table of steam-pressure will be found convenient for reference, as it has been corrected so that it shows the true temperature for any pressure indicated by the steam-gauge. Fractions are omitted and the nearest whole number is used instead. The French table generally used shows 14.7 pounds pressure at 212°, whereas the steam-gauge at that temperature will indicate 0, unless by the expansion of heated air confined in the vulcanizer. The gauge is therefore just *one atmosphere* lower than French table:

Table of the Elastic Force of Steam[1] *(corrected to correspond with the steam-gauge).*

Degrees of temperature, Fahrenheit.	Elastic force in lbs. per square inch.	Degrees of temperature, Fahrenheit.	Elastic force in lbs. per square inch.
212	0	390	205
220	2	400	234
230	6	410	264
240	10	420	296
250	15	430	335
260	21	440	375
270	27	450	415
280	34	460	455
290	43	470	515
300	52	480	565
310	63	490	603
320	75	500	663
330	89	510	721
340	104	520	793
350	120	530	864
360	140	540	937
370	160	550	1015
380	180		

"It will be noticed that as the temperature rises the pressure of steam increases in a constantly increasing ratio for equal increments of heat, the pressure being nearly doubled by the addition of fifty degrees to the temperature. This fact will show the *necessity* of care and watchfulness while vulcanizing.

"The bulb of the thermometer is set in a mercury bath. This is the small cup, forming a part of the vulcanizer cap, to which the thermometer case is screwed. This cup should contain sufficient mercury to ensure its touching the bulb of the tube when the thermometer case is screwed down properly. This makes a *metallic connection* between the thermometer bulb and the vulcanizer cap, and is *absolutely necessary* for the proper indication of heat by the thermometer.

"Should the mercury column separate, it can usually be reunited by removing the tube from the thermometer case, holding it perpendicularly, and striking the bulb with some force upon the palm of the hand, or by holding the tube by the bulb and giving it a sudden flirt. If the vulcanizer is used with the thermometer in this condition, it should be remembered that it is the *whole column* that denotes the heat, and allowance should be made for the broken part; *i. e.*, if there is enough mercury separated to fill the space of 10°, the remainder of the column should only rise to 10° less than the temperature desired.

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[1] General instructions for operating dental vulcanizers, Buffalo Dental Manf'g. Co., July, 1898.

"Directions for inserting a new tube in the thermometer case will generally be found on the package containing the tube and scale.

"Thermometers are accurately marked, by test instruments, at the 212° and 320° points, and the scales are especially graduated for each tube, as the positions of the points above named vary in different tubes. *Each tube must, therefore, be used with its own scale,* and in fitting it to the case, care should be taken that the black mark on the tube indicating the 320° point is brought exactly opposite to the 320° point on the scale.

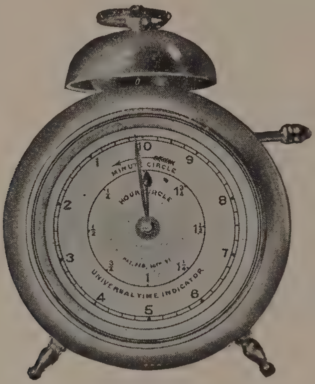


Fig. 392.—Interval timer.

"The thermometer does not always give a correct indication of the heat of the vulcanizer. It only gives the temperature of the vulcanizer top, which may not be that of the flask. In fact, the indications of the thermometers employed on vulcanizers are almost invariably too low, owing to imperfect conduction of heat, radiation, etc.; and the vulcanization temperature, instead of being 320°, as indicated, is more usually 330° to 340°."

The plan of providing a mercury bath for the reception of the bulb is a great improvement over the old way, and prevents the fracture of the bulb by the great pressure of the steam, which was of such frequent occurrence when the thermometer was in direct contact with the latter.

Damage to the glass bulb of the thermometer is manifested by a rise in the mercury, which cannot be brought down to the usual vulcanizing point by turning off the flame of the burner; consequently the thermometer ceases to correctly indicate the degree of heat, and imperfect vulcanization is the result. Leakage of steam around the packing of the vulcanizer should also be guarded against, as in such cases all of the water may escape from the apparatus before the vulcanizing is complete. Loss of all of the water in the vulcanizer may be detected by a persistent fall of the mercury, even when the gas flame is greatly increased, and when this phenomenon is observed, the gas should be turned off, the vulcanizer allowed to cool, and new packing adjusted.

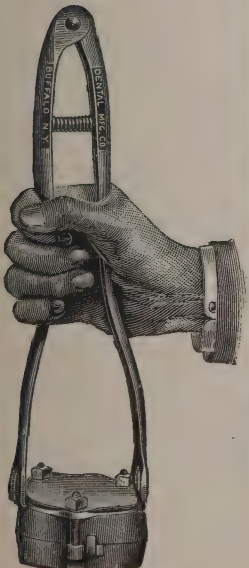

BUFFALO N.Y.
DENTAL MFG. CO.

FIG. 393.—Flask-tongs.

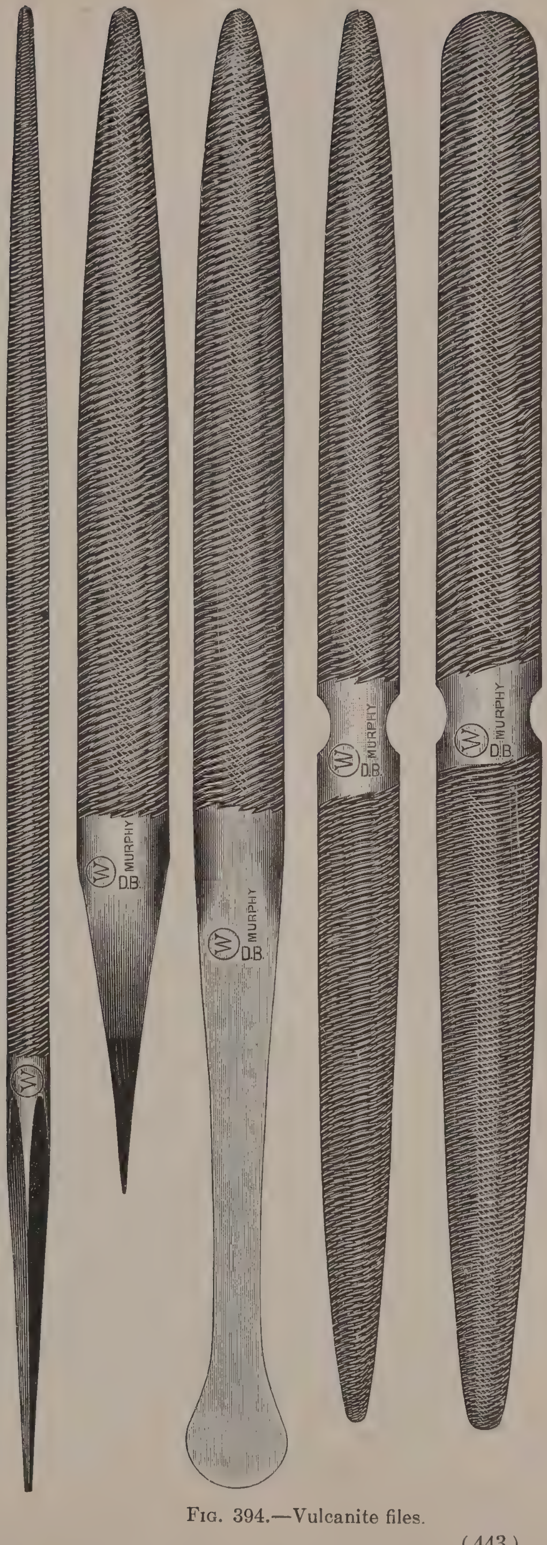


FIG. 394.—Vulcanite files.

Failure to strictly observe this rule has undoubtedly resulted in many serious accidents. An example of this kind occurred some years since in the laboratory of the Dental Department of the University of Pennsylvania. A student was endeavoring to vulcanize with an apparatus which leaked at the packing: noticing that the mercury persisted in falling, he continued to increase the gas flame until the lower part of the vulcanizer was probably red hot. While he stood before it, holding a lighted match to the tube to enable him to see the column of mercury, the vulcanizer exploded with terrific force, sending the top through the ceiling and pieces of the boiler in every direction. It is quite likely that in this particular case the steam was partly decomposed by contact with the hot metal, producing a highly explosive combination of oxygen and hydrogen: no other theory would seem to account for the great force of the explosion.

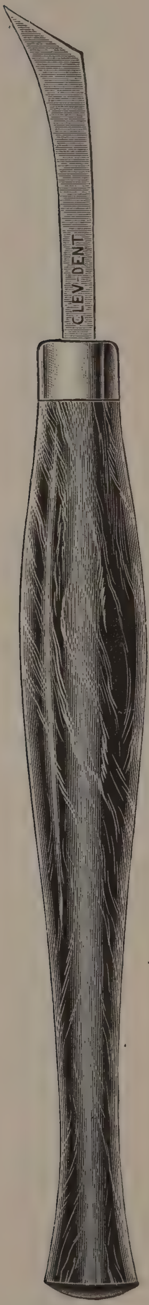


Fig. 395.—Spaulding trimmer.

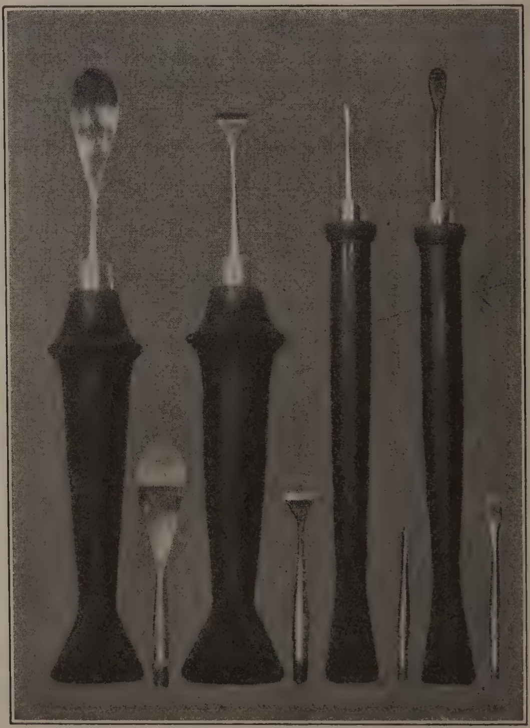


Fig. 396.—Wilson set.

Vulcanizing.—The flask or flasks are placed in the vulcanizer with 3 to 5 ounces of clean water. The packing should be without a break in its continuity, otherwise the steam will escape; the joint between the pot and cover must be protected from adhesion by slightly coating it with black lead or soap-stone. The cover is then put on, but the valve is not closed until the heated air which precedes the generation of steam has escaped; the valve is then closed. A close watch must be kept on the thermometer or gauge until the vulcanizing point is reached unless a time regulator is used.

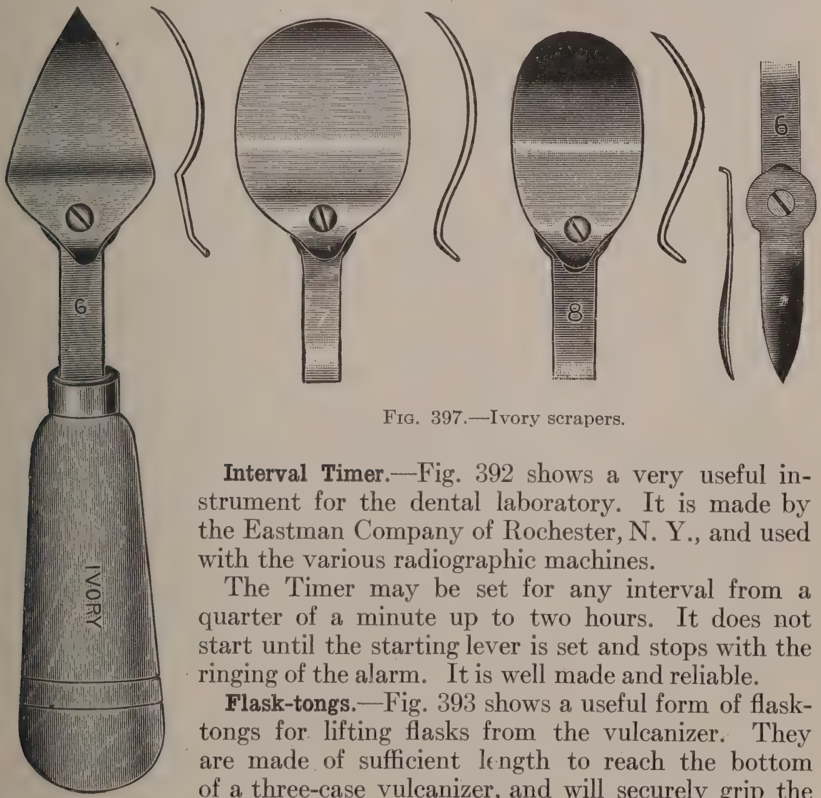


Fig. 397.—Ivory scrapers.

Interval Timer.—Fig. 392 shows a very useful instrument for the dental laboratory. It is made by the Eastman Company of Rochester, N. Y., and used with the various radiographic machines.

The Timer may be set for any interval from a quarter of a minute up to two hours. It does not start until the starting lever is set and stops with the ringing of the alarm. It is well made and reliable.

Flask-tongs.—Fig. 393 shows a useful form of flask-tongs for lifting flasks from the vulcanizer. They are made of sufficient length to reach the bottom of a three-case vulcanizer, and will securely grip the flask.

Files.—Fig. 394 illustrates some excellent forms of vulcanite files.

Scrapers.—There are a great variety of scrapers and chisels from which each operator may select such as seem best adapted to his hand. The writer's preferences are the ones here illustrated. (Figs. 395 to 398.)

OCCASIONAL AND SPECIAL METHODS.

Gum Section Teeth.—There are two varieties of teeth used for the vulcanite base. They are known as plain and gum section teeth. The plain teeth are single and have no porcelain gum, but may have a reproduction of the neck portion of the root of the tooth. The gum sections may be single teeth with a porcelain gum, but usually they are in the form of blocks, each containing two or three teeth. There are various combinations of the teeth in the blocks designed to meet special cases. The plain teeth are used only for the double and single vulcanization methods as previously described, but either plain or section teeth may be used for the single vulcanization sub-method. The gum section teeth require much grinding to adapt them to the wax or hard gum base-plate. The joints between the blocks must be ground to fit squarely against each other and not with a V-shaped space. The case should be flasked at the periphery of the wax. Much care should be used in packing and closing the flask. Do not use too great pressure, as there is danger of checking the porcelain gum and of opening the joints.

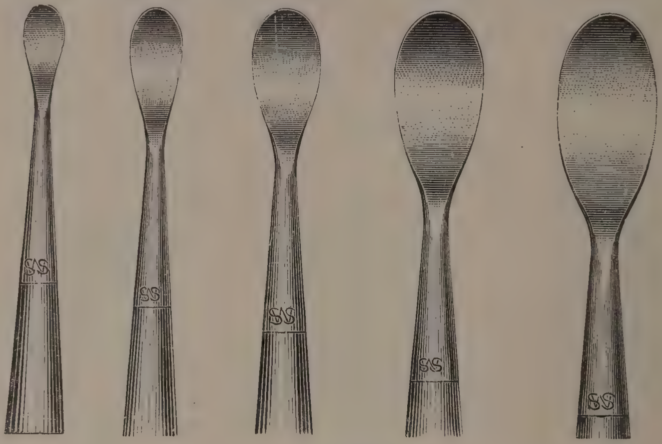
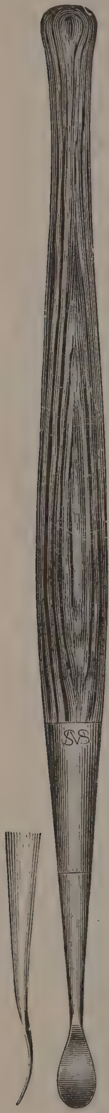


Fig. 398.—Kingsley scrapers.



Advantages and Disadvantages of Section Teeth.—Where the gum portion must be restored and there is extreme mobility of the lip, the porcelain gum will appear to better advantage than the vulcanite gum restoration. In partial cases, blocks of one to four teeth can sometimes be used to very great advantage.

The disadvantages are: (1) the forms of the sections preclude the possibility of the individualizing of the teeth by the dentist, they always have a stiff, unnatural appearance; and (2) there is a space between the porcelain and vulcanite for the accumulation of filth. This last objection does not apply to most of the partial cases requiring gum section teeth, because in these cases the gum portion is not backed up with vulcanite. Some years ago the gum section teeth were in almost universal use, but today there are sections of the country in which sets of fourteen gum section teeth are rarely used.[1]

Plain Teeth Without Gum Restoration.—In many cases of recent extraction, and in a few cases where the gum is sufficiently full after resorption has taken place, no restoration of the gum is required. In these cases the plaster of the cast is scraped away $\frac{1}{32}$ inch for the insertion of the cervical end of the teeth. Without this precaution the teeth in the finished denture would not set closely nor appear to grow from the gum.

Black Rubber Single Vulcanization Method.—Some people fear the effect of the coloring matter in red rubber, so that it may be desirable to construct the denture of black rubber, when it becomes very necessary that the black rubber should not show upon the labial and buccal surfaces. The two rubbers can be packed in the usual way or by this very ingenious method.[2]

Dr Slabaugh's Method.—"After separating the flask and boiling out the wax, I coat the cast with silex and then lay on my black or red rubber loosely over the cast. I then take a piece of the cloth that comes on the sheets of rubber and lay it over the rubber that is on the cast, and place the two parts of the flask together and set them in boiling water for a few minutes, after which I place the flask in a press and force it together, care being taken to have the flask entirely together. The flask is entirely filled with the rubber. I now separate the flask and the rubber will adhere to the cast. Remove the cloth that has been put on and you will have perfect imprints of the teeth and pins in the rubber that have been made through the cloth. I then place a narrow strip of pink rubber on the black or red over the imprints of the teeth and up to about $\frac{1}{32}$ inch of the imprint of the pins. Place the two parts of the flask together and force them down and it is ready for the vulcanizer. Cut waste gates only in the rear so that when the flask is closed the second time with the little piece of pink rubber added to it, the slight displacement of black or red rubber will be entirely toward the rear."

Waxable Rubber.—A few years ago this material was placed before the profession by John Hood & Co., Boston. Its physical properties are very much like those of sheet gutta-percha. It is not a patented article. The claims for the material and the method of construction are given as follows: "An entirely new process with a material far superior to rubber—much lighter and one that will not become slimy in the mouth. To use, hold a sheet over the burner the same as a sheet of wax and make a trial plate; build out with rubber to the desired fulness and put the teeth in place with a spatula, by keeping the rubber soft and heating the tooth. Use the rubber just as you do wax, and smooth it before adding pink rubber. After it is cool, add the pink rubber by first removing the teeth without heating, leaving the impression of the teeth in the rubber. Cut a strip of pink rubber wide enough to reach the ridge and cover the indentations of the teeth, just above the pin holes, and to reach from heel to heel. Soften the rubber slightly and heat the tooth and replace it, carrying the pink rubber under the neck of the tooth. In this manner you can make a natural festoon as full as is desired. Care should be taken not to make any finger-nail marks or to mar the pink rubber. After the teeth have been tried in, before placing on the cast, paint the cast with the solution and heat the plate, pressing it in place with the fingers. Smooth the red rubber by the use of chloroform on a cloth. Moisten the cast and drive the air from it. Fill the flask with plaster and press in cast, shaking the flask well to prevent bubbles. Vulcanize, taking twenty-five minutes to run up, and then hold it one hour at 315° F."

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[1] The writer has put up but one set of gum section teeth in thirty years.

[2] Dr. Frank W. Slabaugh of Omaha, Neb.

Thick Vulcanite.—Thick masses of rubber may be vulcanized by gradually increasing the heat from 280° to 300° F. Another method is to fill the mold with vulcanite, having the rubber packed about it; or the mold may be largely filled with pink rubber.

REMOVING THE TEETH FROM A VULCANITE DENTURE.

Sheet Iron Method.—Place the denture, teeth downward, upon the sheet iron over a gas stove, and when the vulcanite is thoroughly softened, the teeth may be pushed off one at a time by inserting the wax spatula between the tooth and the vulcanite upon the lingual side. The plate is held by a pair of pliers and the dislodged teeth are permitted to fall upon wood, or better, upon cloth, but not upon cold iron or stone. Any portion of the vulcanite remaining about the pins should be removed. If necessary, these small portions of vulcanite may be softened by grasping the tooth in a pair of solder tweezers and holding in the Bunsen flame.

Glycerin Method.—The denture is placed in a vessel of glycerin and heated to the boiling-point of the liquid, when the teeth can be removed as in the other method. The glycerin is soluble in water and easily removed. The fumes of the heated glycerin are more objectionable to some than those of the overheated rubber.

Flame Method.—The denture is grasped with a pair of pliers and the outer surface of the teeth heated by passing repeatedly through the flame until the vulcanite is softened about the pins, when they are removed as before described.

It is not advisable to remove the teeth by heat from a denture which is to be used again, because of the liability of warping the plate. The vulcanite should be cut from about the pins of the tooth with a bur in the engine or with a chisel.

Partial Cases.—It frequently occurs in constructing partial artificial dentures for the replacement of single incisors or canines that the ordinary vulcanite teeth are too thick to admit of their being arranged to conform to the line of the natural teeth without interfering with the normal occlusion. In such cases a plate tooth may be used, and is attached by means of gold backings, bent at an angle with the base of the tooth, of sufficient length to allow of the projecting portion to be imbedded in the rubber plate. The extension of the gold backing has two or more holes punched and countersunk in it, so as to be held firmly by the vulcanized rubber.

Gold Clasps.—Gold clasps, when used in combination with rubber, are attached in the same way. The clasp, after being accurately fitted to the plaster tooth, is provided with a piece of gold plate soldered at a point next to the rubber plate. This attachment should be slightly raised from the cast, so that it will be entirely enveloped by the rubber.

There is some danger of these clasps being forced slightly from their correct position by the pressure of the rubber in packing. This difficulty may be entirely overcome by soldering a temporary support of scrap gold to the clasp and bending it over the plaster tooth. Usually this device will be found effective in retaining the clasp in contact with the tooth. After vulcanizing, the supporting piece of gold may be sawed off with a jeweler's saw. In packing a case arranged with gold clasps, a thin sheet of rubber should be worked under the gold attachment to further protect the latter from displacement. It will, of course, be understood that the clasps are to remain in position during the packing; therefore, in flasking such cases the plaster should be made to cover the portion of the clasp not actually in contact with the rubber; this affords additional support to the clasp during the pressure accompanying the closing of the flask in packing, and will keep it in correct relation to the plaster tooth.

Partial Lower Vulcanite Dentures.—Gold is used in combination with that class of partial lower dentures designed to replace the bicuspids and molars and when the natural incisors and canines remain. For the purpose of strengthening the piece and to lessen its bulk in front, a plate of gold is sometimes swaged to fit the cast back of the front teeth, and where the ridge is not well defined and not favorable to the retention of the piece without some form of attachments, gold clasps are soldered. The gold plate is allowed to extend somewhat beyond the canine teeth; the ends are perforated by the punching forceps, to ensure strong union with the rubber. This plate is then put upon the cast and secured in place by means of wax; the teeth are arranged in position, waxed up, and vulcanized in the usual way. The denture when finished presents to view a plate with the anterior part of gold, while the two parts holding the teeth and resting upon the ridge on each side are of vulcanite. The purpose of such a combination is to save labor and material, but a denture so constructed, while better in point of durability and because of the absence of bulkiness where it passes around back of the incisors and canines than vulcanite alone, is

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still far inferior to one constructed entirely of gold, for while such a denture is doubtless stronger than one of vulcanite alone, it is not so durable as one made exclusively of gold, on account of the liability of the piece to break at the points where the gold is embedded in the vulcanite. Dentures of the class above referred to should always be made entirely of metal, and the expenditure of money and labor is but little greater than in the combination plan, while the general result is in every way more satisfactory.

Dr. P. T. Dashwood uses in place of the swaged plate above suggested for the anterior portion of lower partial dentures, an iridioplatinum wire, gauge 14, which is bent with round-nosed pliers to conform to the lingual alveolar surface. The ends are flattened upon an anvil and cross pieces of platinous gold are soldered to them for the attachment of the vulcanite. He makes the just claims that the wire is "stronger than vulcanite, is much more comfortable to the patient, and is more hygienic."

Natural Teeth upon Vulcanite Base.—Where the anterior natural teeth have become so loosened by the ravages of pyorrhea alveolaris, by excessive resorption of the gums and sockets or of the roots of the teeth, so that their complete loss is a matter of a very short period of time, a plaster impression may be taken of the mouth before the removal of the loose teeth.

In constructing partial dentures for cases where the natural organs are prematurely lost, it is much the better practice to reset the natural teeth, provided, as is often the case, they are of dense structure and have not previously been attacked by caries. This is done by making a plate in the usual way, and in the spaces to be occupied by the natural teeth, vulcanizing a strong platinous gold wire, being careful to place the gold pin in the center of the space. The wire must have an attachment soldered to it, so that its connection with the rubber will be secure. The wire may be arranged with a simple piece of scrap gold soldered to the end to be embedded in the rubber, or it may be provided with a perforated extension, by which union with the rubber may be secured and great bulkiness avoided. The rubber portion of the denture finished, it only remains to remove the infirm natural organs and attach them to the plate made ready for their reception. This is done by sawing off the roots, enlarging the pulp-canal with a suitable engine drill, fitting the neck of the tooth to the plate, and into the socket, and then attaching the tooth to the pin and plate by means of zinc-phosphate cement, being careful to dry the parts thoroughly before the cement is applied. This method of resetting natural teeth is more conveniently done on gold plates than on those of rubber, but it is applicable to both. It possesses the following advantages: (1) The teeth are the patient's natural teeth, and this fact very greatly lessens the repugnance which many individuals of exalted sensibility feel to artificial teeth. (2) It saves the individual from being seen without teeth—a matter of the greatest importance to many patients. (3) Artificial appearance is avoided, for they are the natural teeth of the patient, and nothing more need be said on the score of natural effect. The question is often asked, Do teeth reset in this manner suffer from dental caries? It has been observed that such teeth are not more liable to decay after their attachment to a plate than they were before removal from their sockets.

If the infirm natural teeth are of poor quality and have large fillings in them, it is better to use porcelain teeth, and the dentures can be entirely finished ready for insertion before the natural teeth need be extracted. Care should be observed to allow the necks of the artificial teeth to extend well into the sockets of the extracted organs, to anticipate resorption of the parts which to some extent is sure to occur at such points.

Combination Dentures.—Under this heading are included metal plates with vulcanite attachments, vulcanite plates with metal linings, vulcanite dentures strengthened with perforated metal plates, etc. Excellent results may be obtained by attaching the teeth to metallic plates by means of vulcanized rubber. A denture so constructed will be found to possess greater strength than one of vulcanite alone, while it will have the additional advantage of being free from interstices, which favor the lodgment of decomposable débris. In other words, the combination of metal plate with vulcanite attachment thoroughly meets the objections raised against either method alone.

Either gold, silver, platinum, aluminum, palladium silver, or any of their alloys usually employed in prosthetic dentistry, may be used in the construction of one of these combination dentures; preference, however, should be given to gold or palladium silver as a base. Platinum unalloyed is not well adapted for the purpose, on account of its great ductility and weight, but when alloyed with a small percentage of iridium its rigidity is so much increased that a plate of No. 29 thickness will be found to be quite as strong as a much thicker plate of 18-carat gold.

Either ordinary silver plate of standard[1] fineness may be used with rubber attachment, or silver alloyed with platinum, the latter having greater tensile strength than the former. It must be remembered, however, that silver has a powerful affinity for sulphur, the indurating agent in vulcanite, and that the presence of platinum as an alloy does not entirely protect the silver from the action of the sulphur. It is, therefore, necessary, where a silver plate is used, to interpose a layer of No. 60 tin-foil between the rubber and the plate; this precaution, however, is not necessary where celluloid is used.

In silver dentures with vulcanite attachments the anchorages must invariably be made of platinum or gold wire. After the plaster wall is made and the wax removed from around the teeth, the exact positions of the anchorages are marked upon the plate with a sharp steel point to the number of eight or ten. The plate is then laid on a charcoal support and pieces of silver solder are fused at the points indicated. The wire is then cut into proper lengths, screwed in a vise, and one end of each flattened by means of a rivetting hammer into the form of a head; each pin is then taken up separately, the headed end dipped in borax, and placed on the plate at a point where a piece of solder has been fused. The borax will assist in retaining the piece of wire until the flame of the blowpipe is directed upon it to remelt the solder and unite the pin to the plate. The wire anchorages are not to be bent into hook form, as shown in Fig. 401, until after the tin-foil protection has been adjusted. The pins are forced through the tin-foil and pressed with a rubber point and burnished closely to the plate. The holes made by the passage of the pins through the tin-foil, if care is used, will not be large enough to allow the rubber to reach the silver to any great extent. After the tin is in place the pins may be bent with pliers, as shown in Fig. 401.

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[1] Coin.

Another method is by directly tinning the surface to be covered by the rubber. The silver is cleansed and covered with a saturated solution of zinc chloride. The tin-foil is pressed carefully against the silver and the plate is held above a Bunsen flame until the tin fuses. Its flowing is to be directed by means of a camel's-hair pencil which has been dipped in the zinc solution.

Vulcanite in Combination with Plates of Fusible Alloy.—For the modus operandi of the preparation of plates of fusible alloys, the reader is referred to Chapter XIII. The Reese or Weston fusible alloys can be cast very thin, and yet are sufficiently rigid to withstand the force of mastication. These alloys retain their color and make an admirable combination plate. Having finished the plates as shown above, the edges and raised rims are trimmed to the desired dimensions. A roll of softened modeling compound or wax is pressed around the gums over the alveolar ridges, and trimmed with a knife to the supposed height of the teeth. The plates are then tried in the mouth, and the wax trimmed from all sides until perfect occlusion and contour are obtained. The median line is marked on the modeling compound or wax, as the case may be, and the cutting edges marked in several places to serve as guides in restoring the upper and lower waxes to their correct relation with each other should they become separated. The articulating models are prepared in the usual way—pouring plaster into the lower plate, first allowing it to extend back sufficiently to receive the upper half, which is to be poured next. The modeling compound or wax is then to be removed and the teeth arranged and waxed up and vulcanized. The attachment of the vulcanite to the plate may be secured by freely nicking the ridge to which the teeth are to be fastened by means of a sharp-pointed graver, but without this the undercut of the rims and buttons will be ample to hold the vulcanite securely to the metal.

Aluminum, though not affected by sulphur, is not as well suited for vulcanite attachments as the other metals named, on account of the want of reliable aluminum solder with which to fasten the loops or pins thoroughly; but by special treatment, which will be described in connection with the manner of preparing aluminum plates, a comparatively durable denture can be made of that metal with vulcanite. Recently casting methods have been so improved as to make the use of cast aluminum with a vulcanite attachment a thoroughly satisfactory procedure.

In constructing a denture of gold with vulcanite attachments the plate should be of the thickness of No. 27 of the standard gauge, and made in accordance with the directions for the making of gold and silver plates in Chapter XII.

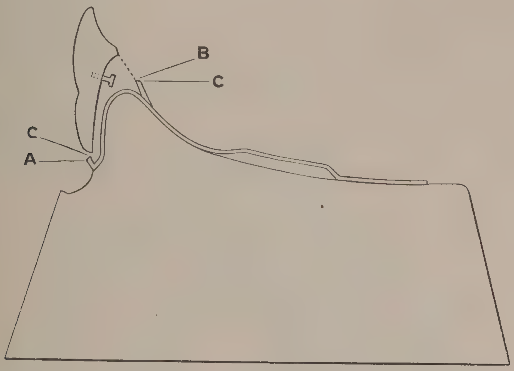

Fig. 399.—Cross-section of gold plate showing soldered rim.

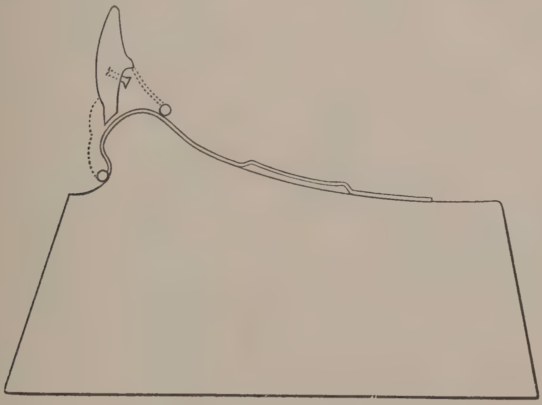

Fig. 400.—Wire rim.

It should be provided with a rim extending entirely around the labial and buccal edges and upon the palatal portion of the plate slightly posterior to the alveolar ridge, as shown in *A* and *B* in Fig. 399. This rim may be formed of No. 27 plate (Fig. 399) or round wire of No. 17 gage (Fig. 400). A rim formed of round or triangular wire requires much less labor and time in its adjustment and soldering than if formed of a strip of plate, and when flattened with the file on the labial side, and the corborundum wheel and graver on the lingual side, it has the same effect as if it were formed of plate.

The rim may be dispensed with entirely, but, as it gives a more finished appearance to the denture and adds greatly to its strength, it should, therefore, always be preferred.

In attaching a flat rim to a gold or silver plate, a strip of plate long enough to extend entirely around the rubber attachment should be cut. The rim should be annealed, and bent with the pliers to fit the labial and buccal edges on the plate. It is then placed on a charcoal support, and the rim held in contact with the plate by means of small nails or tacks; it is then united to the plate by a small piece of solder immediately in front at the frenum and at one or two other points along the buccal edges. The plate is then cooled, placed upon the plaster cast, and with a small hammer and pliers the rim is brought in close enough contact with the plate to admit of complete soldering. The lingual portion of the rim should not be soldered to the plate until after the correct position of the teeth has been ascertained. This is accomplished by arranging the teeth according to the bite and other requirements of the case, and then making a wall of plaster around them separated at the center line. This enables the operator to mark upon the plate with a sharp instrument the correct point at which to solder the rim, so that it will leave an unbroken surface for the tongue, as shown by *B* in Fig. 399, and to mark the proper position for the loops or bent-pin attachments, as shown by *C* in Fig. 401. It is very important that the exact location of these fastenings should be ascertained, but this cannot be determined until after the teeth have been adjusted.

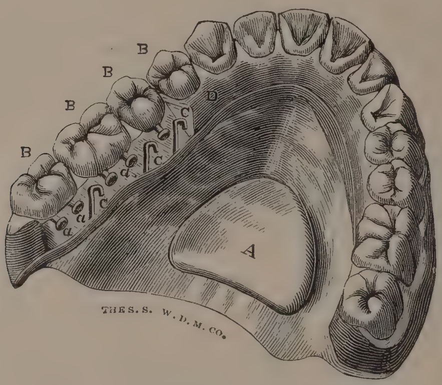

FIG. 401.—Location of wire attachments.

The wire rim is soldered to its place by simply clamping the wire to the plate, and then attaching it at single points in front and at the buccal edges, and, after the correct position of the teeth has been ascertained, bringing it entirely around at the lingual portion, as shown by *C* in Fig. 401. By simple pressure with an instrument or gently tapping with a riveting hammer, it may be brought into close contact with the plate and completely soldered. It need not be flattened and finished until after the case is vulcanized.

Owing to the difficulty in soldering aluminum, it is necessary to secure attachment for the vulcanite to the plate by means of perforations or countersunk holes along the top of the ridge. For this purpose, ingenious perforating punches have been devised by Drs. Richmond, Peck, and others; those of the two former are shown by Figs. 402 and 403, the latter throwing up a sharp square bur, the former a loop. The punch points, entering from the under side of the plate, produce the desired result without in the least bending or affecting the fit of the plate.

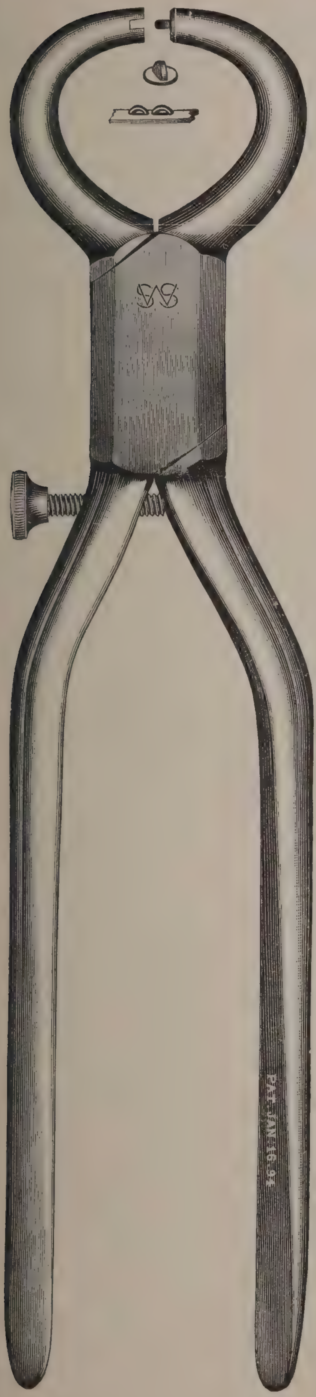

Fig. 402.—Loop punch.

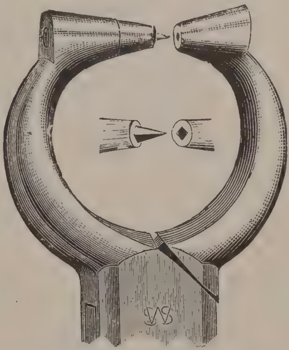

Fig. 403.—Perforating forceps No. 9.

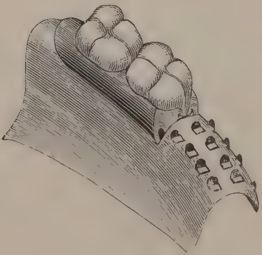

Fig. 404.—Perforated plate.

A rolled aluminum plate, constructed in the manner shown by Fig. 404, and roughened by means of the punches (Figs. 402 or 403), and with the teeth attached by means of vulcanite, will afford a light, strong and comparatively durable denture.

Vulcanite is of great value in refitting gold dentures which have ceased to fit the mouth in consequence of changes by resorption following the extraction of the teeth. These changes may continue in some cases for several years after the removal of the natural organs, to such an extent finally that the denture will no longer be of service. The resorption usually occurs along the alveolar ridge, and it is a matter requiring but little time or labor to adjust the denture to a new plaster cast, fill the spaces caused by resorption with wax, invest, pack, and vulcanize the piece. Care must be observed to make countersunk perforations through the plate at points where the vulcanite is to be attached, so as to secure firm union with the gold plate.

Special Rubber Facings.—Two kinds of rubber have been introduced in the past that commend themselves for use in the combination plate described above. One is the "granular-gum" rubber facing by Dr. Gilbert Walker, in the use of which the following directions are given: "In waxing up a case, carefully model the gum portions to the exact contour desired, and make the festoons smooth at the necks of the teeth. After flasking, face with a layer of granular gum cut to lie close around the labial and buccal necks of the teeth, and pack against the outer wall of the plaster investment, so that the facing shall not extend above the edges of the plaster. Lap the pieces of granular gum carefully, so that the red rubber will not be squeezed between them, and show on the facing after vulcanizing. In packing the red rubber care must be taken not to have an excess, else the overflow may carry with it the granular gum and elongate its colored particles, thus interfering with the mosaic appearance on which the imitation of the gum depends.

"The lingual part of the plate may likewise be faced, with care in lapping the pieces of granular gum and avoiding an overplus of red rubber. With this form of rubber, exposure to sunlight for the purpose of developing its color is unnecessary; when well polished the moisture of the mouth will improve the tint.

"Granular gum vulcanizes with any of the ordinary rubbers; better results are, however, obtained by vulcanizing it at a low temperature. In finishing, care should be exercised to avoid cutting through the thin facing."

Gear's shaded pink rubber is somewhat similar to the granular gum described above. It may be used in the same manner as the latter, and adds greatly to the beauty and natural appearance of the gum portion of the denture if the preliminary modeling has been done with taste and skill.

Vulcanite Dentures with Contours.—It is sometimes necessary to amplify the denture at points where unnatural depression occurs in consequence of great resorption following the loss of canines or molars. If the amount of projection required to restore natural expression is not extraordinary, slight additions to the rim and the usual vulcanizing may be relied upon to accomplish the desired result; but if the case require a large mass, exceeding $\frac{1}{4}$ inch in thickness, the vulcanizing must be done at a lower temperature, of, say, 300° F., and three hours' exposure in the vulcanizer, in order to avoid porosity. Equally good results may also be attained by forming a core of some light material, enveloping it in rubber, and filling with it the recess in the flask representing the "contour." For this purpose cores of thin metal hermetically sealed, approximating the form of the contour and $\frac{1}{8}$ inch smaller than the latter may be used. The preparation of metallic forms is, however, a matter requiring considerable labor and time. A much simpler and equally effective method is to form a core either of vulcanized rubber, sponge, or cotton-wool tightly rolled and wrapped with thread. In packing, the core is not to be placed in position until the case has been packed and the flask completely brought together, when it may be opened, the recesses representing the contours freed from rubber, and the cores, previously wrapped with strips of soft rubber to the thickness of $\frac{1}{8}$ inch, put in its place. The object of first packing and closing the flask is to prevent the flow of rubber from displacing the cores and to insure their complete envelopment. In finishing such a case, care must be exercised to avoid cutting through the rubber or exposing the sponge or cotton when those materials are used. Probably of the materials named, a piece of hard vulcanite affords the best results and is less likely to lead to failure through displacement, which is always liable to occur.

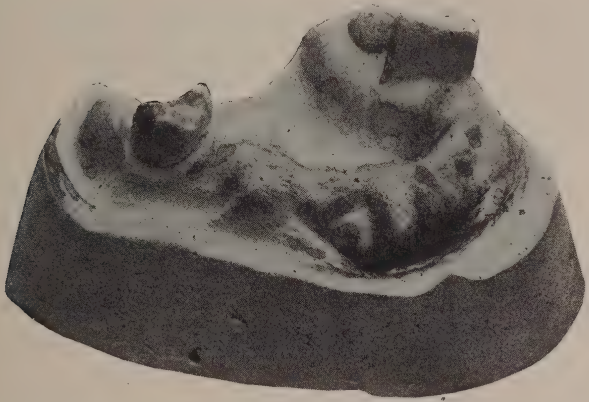

Fig. 405.—Cast of mouth with opening into nasal cavity.

The same course as outlined above in the preparation of ordinary contours may be pursued in making plates to restore contours when large portions of the maxillary bones have been lost by disease or accident, such as gunshot wounds, etc. Fig. 405 shows a cast of the mouth in which the whole anterior portion of the alveolar ridge had been removed, leaving a large opening into the nasal cavity, by which speech was seriously affected. After obtaining the cast, a thin plate of wax was prepared to cover the palatal portion extending around the teeth in the form of half clasps, and through the opening even with the floor of the nasal cavity. Upon the wax base thus prepared the artificial teeth were arranged, and the waxing and flasking done in the usual way. To prevent porosity of that part of the vulcanite appliance which extended into the opening, two or three drops of water were introduced, so as to keep the bulb hollow and in a state of expansion during the vulcanizing process. This water may be removed after vulcanizing by drilling into the bulb and then securely plugging the holes thus made with platinum wire tightly screwed in. Fig. 406 affords a sectional view of the appliance.

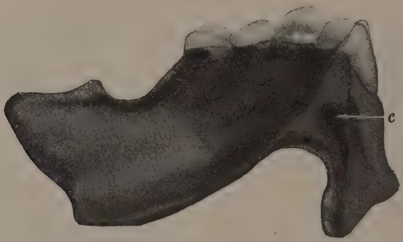

Fig. 406.—Denture constructed for case shown in Fig. 405.

Spiral Springs.—Vulcanite dentures are occasionally retained *in situ* by means of spiral springs. This method of retention is, however, but seldom resorted to, except in cases of oral deformities.

Vulcanite Dentures and Flexible Rubber.—The use of "velum rubber" (soft vulcanite) retainers is a questionable method. It is certainly unsanitary and rarely justifiable. There are two general plans for using velum rubber: (1) As a peripheral border of the relief chamber, or the outer edge of the plate. (2) In the form of disks, either as a large central disk or as small disks distributed about the surface. The rationale of the first method is to provide a flexible rim that may be readily adapted to a thin tense mucous membrane. In such cases the method has the stamp of being scientific, but it is unscientific and has the stamp of ignorance to use the method when the tissues are excessively soft and stability is the result desired. The second method consists of attaching soft vulcanite disks to depressions in the maxillary or mandibular surface of the denture (Fig. 407). The rationale of this method is that the thin pliable disk, by the aid of moisture, easily conforms to a surface covered with thin and tense mucous tissue;

then as stress is applied to the denture it draws the center of the disk away from the tissue, thus forming a vacuum. It is obvious that such a denture is pendently seated, but that it will require much force to remove it from the mouth. The mouths where such methods are indicated are rare, and to insert such unsanitary appliances, when other methods, properly used, would meet the requirements, is reprehensible. As velum rubber contains but one-third as much sulphur as hard vulcanizable rubber, it is evident that the soft vulcanite is but one-third "cured;" therefore it is easily understood why the material is so much less durable, swells, changes form, acquires an offensive odor, and requires renewal every few months. "Velum rubber" should never be used in the mouth except where the conditions cannot be met by other means, and then it should be renewed often.

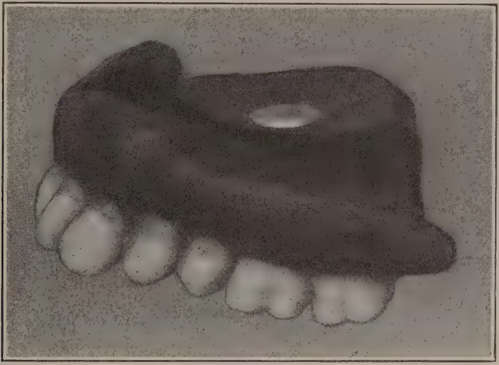

Fig. 407

There are conditions of the lower jaw that can be met with velum rubber better than with any other material; however, even in these extreme cases the material should be used only as a last resort, and then only after the patient has had explained the nature of the material and the continued expense.

Conditions of the mandible indicating velum rubber are: excessive resorption with nodules and sharp ridges upon the surface of the bone, and soft tissues very thin and sensitive, especially to a sliding movement.

The technic for constructing a hard vulcanite denture with a velum vulcanite lining is peculiar to the material, but easily comprehended.

The compound cast and wax occlusion model having been obtained, are mounted upon an articulator. The wax occlusion model is now laid away for future use. The surface of the mandibular cast should be freed of all wax and the surface rubbed with talcum powder. A piece of thin tin-foil is smoothly and perfectly adapted to this powdered surface, upon which the denture is to rest, one thickness of pink base-plate wax, and over this a layer of heavy (No. 60) tin-foil are conformed. This represents the portion to be replaced with velum rubber, and is called the base-plate; upon this foundation of tin and paraffin, or base-plate, a small roll of soft yellow wax is placed, in which a soft-iron wire is embedded for rigidity. Upon this roll of wax the teeth are mounted and occluded. This built-up trial denture is tried in the mouth and if satisfactory is returned to the articulator; the yellow-wax rim mounted with the teeth is thoroughly chilled and carefully removed from the base-plate. This teeth-mounted wax rim not being distorted, is flasked, packed with hard vulcanizable rubber, and vulcanized. The hard vulcanite rim is thoroughly polished, except the base surface, which is scraped and the edges filed to a slight bevel looking outward. This vulcanite rim is now returned to the articulator, occluded, and waxed to the paraffin-tin base-plate. The entire labiobuccal and lingual surfaces are nicely covered with heavy tin-foil, even extending upon the porcelain teeth. (Remember the original cast is upon the articulator and is to remain there.)

The tin-covered denture is now flasked with French's Regular Dental Plaster so that the separation is exactly at the periphery of the base-plate. The flask is opened and the base-plate removed. The cast upon which the velum rubber is to be vulcanized is now in the lower section of the flask and was formed from the mandibular surface of the tinned base-plate. If the tin was carefully formed upon the compound cast and the first half of the flasking carefully done, the new cast will be a perfect reproduction of the original. This is to be covered with thin tin-foil and soaped. The next step is a very important one. The exposed surface of vulcanite must be thoroughly cleaned of wax and dirt; flush away the wax with hot water, wipe dry, and rub well with a cloth saturated with chloroform. This surface is then covered with a hard vulcanizable rubber cement (bow-spring rubber dissolved in chloroform to the consistency of thick cream). The cement is evenly painted over the surface of vulcanite, and when the chloroform has nearly evaporated, sufficient velum rubber (preferably black) is packed upon it to fill the mold. Vulcanize the same as hard rubber. When the case is taken from the flask and the tin-foil removed, it is finished except the peripheral edges of the velum rubber. These edges are trimmed away with sharp scissors, seared with a hot iron, and the burned soft vulcanite removed with chloroform. In a few moments the chloroform will have evaporated and the case is finished; however, it is well to again gloss the hard vulcanite with a soft brush-wheel and chalk.

The articulator bows mounted with the original casts and wax-occlusion model are filed away for future use.

When it becomes necessary to renew the velum rubber, the bows mounted with the casts and occlusion model are returned to the antagonizer, the velum rubber is cut away until a surface of hard vulcanite is obtained, a new tin and paraffin base-plate is formed, and the teeth upon the hard rim of rubber are occluded and attached to the base-plate. The remainder of the process is the same as constructing the original velum lining.

As all the strength of this denture is in the hard vulcanite, it is well to use a reinforcement. This is done by inserting a No. 12 to 16-gauge wire of clasp gold or iridioplatinum. This is done when packing the hard vulcanite rubber. With the pins of the teeth embedded in red rubber and the pink rubber facing in place, the wire stiffener, previously conformed, is placed at the cervix of the teeth and the packing completed.

The technic for applying the tin-foil has previously been described.

REPAIRING VULCANITE DENTURES.

The breaking of vulcanite dentures is usually due to over-vulcanizing, by which elasticity and toughness are destroyed; to improper arrangement of the molars, by which the strain of mastication is thrown on the outside instead of on top of the ridge; or to a warped denture. The first evidence of the giving away of a piece is usually a fine crack appearing between the two central incisors, and sometimes, in partial dentures, in the border surrounding a natural tooth.

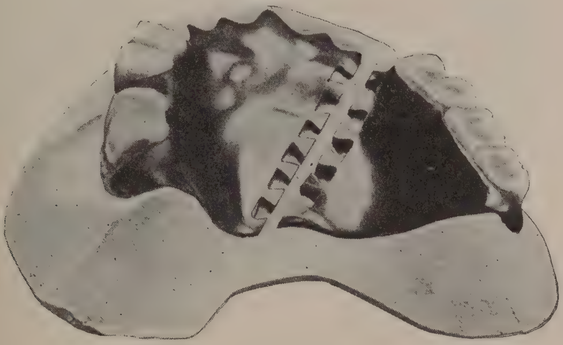

FIG. 408.—Fractured vulcanite denture dovetailed for repair.

Wax Method.—A method particularly applicable to dentures which are broken entirely in two, consists in adjusting the two parts of the denture together, and fastening them in correct relation to each other temporarily by adhesive wax dropped on the lingual surface until plaster can be run into the maxillary portion of the denture. As soon as the plaster hardens, the denture is removed from the cast, the line of division is enlarged with a file, and dovetails cut opposite each other with a jeweler's saw, as shown by Fig. 408. The dovetailed space is then filled with wax, invested in the usual way in a flask, packed, and vulcanized. This method is open to one serious objection—it necessitates another vulcanizing and the consequent loss of elasticity and toughness. A plate so treated will never be as strong as it was before. By another method the edges may be adjusted as before described, and the piece be placed immediately in the lower half of the flask. After the plaster has set, the adhesive wax is to be removed from the lingual side of the plate and a line cut with a round engine bur along the full extent of the crack, or break, halfway through the plate and a quarter of an inch wide, with smooth, regular edges, without dovetails. The case is then waxed up and the other half of the flask poured—when the case is packed and vulcanized. If the parts have been kept perfectly clean the union will be quite strong.

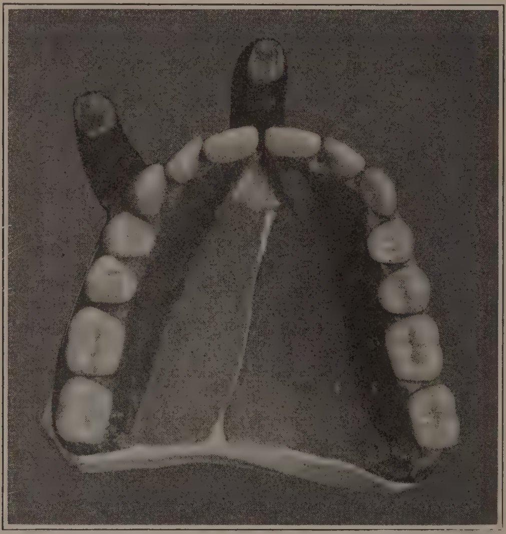

Fig. 409.—Fractured vulcanite denture prepared for repairing with beveled surface and wax shafts.

Another modification,[1] which gives the best results is this: After the cast is made, the portions of the plate are removed from the cast and with file and scraper a long bevel is cut, forming a thin feathery edge along the fractured edge and sloping away from this for an $\frac{1}{8}$ to $\frac{1}{2}$ inch as the case will permit (Fig. 409). The pieces are then filed to give a slight bevel upon the maxillary surface. The portions of the denture which have been cut away are replaced with wax, and if necessary the denture may be thickened over the portion having the freshly cut surface. It is unnecessary to coat the vulcanite surface with a solution of rubber as the heat and pressure will make the union. Fig. 410 shows method of flasking. (For description of wax shafts, see page 422.)

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[1] The method preferred by the writer.

Fusible Metal Method.—To avoid loss of strength by the second vulcanizing, it is recommended that fusible metal, melting at 150° or 160° F., be used to fill the dovetailed space. This can be done by pouring the melted alloy into the space and packing it with a hot spatula, which is readily admissible owing to the low fusing-point of the metal. While the method has the advantage of not requiring a second vulcanizing, the union of the metal at the point of fracture is not as close as when rubber is used, and it cannot be said to be reliable as a means of repairing broken vulcanite dentures.

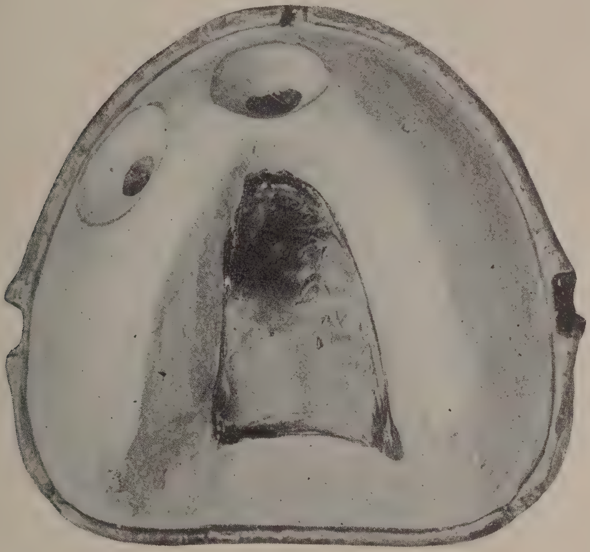

Fig. 410.—Fractured vulcanite denture shown in Fig. 408 invested.

A single tooth may be fastened to the vulcanite by filling the dovetailed space as for repairing with rubber, the fusible metal to be put in place with a hot spatula; or the dovetail can be filled with amalgam.

Replacing Vulcanite Method.—Much the better way is to fasten the parts together, run a plaster cast into the denture, then make a bite of plaster to serve as a guide for the replacement of the teeth, remove the latter from the broken plate, reset them to the cast, wax up the piece, flask, and vulcanize. This affords practically a new case, and the time consumed is not much greater than is required in repairing the old one.

Additions to Old Dentures.—Additions of teeth to old dentures are accomplished after practically the same methods. Fig. 411 shows a case where four teeth have been extracted, and the old plate is prepared for the addition of as many porcelain teeth, so that the denture could be worn until the resorption of the alveolar ridge and gums would admit of the construction of a permanent denture. The illustration shows the denture bevelled off to a smooth edge, and several holes drilled into the filed portion. The correct occlusion of the new teeth is obtained by placing the denture in the mouth after the bleeding ceases, placing two pieces of softened wax along the alveolar ridge and plate, and directing the patient to bite into the wax, and then gently pressing the wax while the teeth are in contact. This gives the correct relation of the lower to the upper teeth, and the impression of that portion of the alveolar ridge to be covered by the addition to the denture. The preparation of the plaster cast and bite is done in the usual way, plain teeth being ground to the gums to allow for the rapid resorption which always follows the extraction of teeth. The waxing and flasking are done in the usual way.

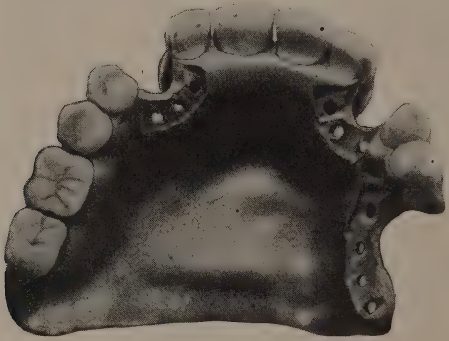

Fig. 411.—Denture prepared for the addition of several teeth.

Ironing-in Method.—This method is suitable for replacing a tooth or two, or filling a short crack or a hole. The vulcanite is cut with a file to give a dovetailed form to the space into which a tooth is to be added; and a crack or hole should be prepared for the new rubber with a scraper. The new rubber is ironed into place by using a hot wax spatula and firm pressure. Waxable rubber is better for this work than ordinary rubber.

APPENDIX.

PORCELITE.

Vulcanite as a denture base has served a very valuable place in dentistry. It came into use at a time when the prosthetist was badly in want of just such a material for his definite needs. Now there is a demand for a more modern and better material and the day of the vulcanite denture is drawing to a close.

Many different kinds of materials have been experimented with and results have been discouraging. The general demand for a better base material and the seriousness of the group of investigators gives promise that results will soon be obtained. The most advanced work along this line seems to have come from experimentation with a modified form of Bakelite, a compound of or condensation product of formaldehyde and phenol, and is known as porcelite. It was developed in the research department of the M. F. Patterson Dental Supply Co., of Minneapolis, Minn. While this material is, at this writing (November, 1927), too new to say much regarding it from a practical standpoint, sufficient work has been done to give every assurance that it or a similar material will prove far superior to vulcanite as a denture base.

The technic of constructing porcelite dentures is but little different from that of vulcanite except that it is somewhat more exacting. The wax pattern, as well as the cast, must be carefully tin-foiled, and vulcanization is accomplished by placing $\frac{1}{2}$ inch of denatured alcohol in the pot of the vulcanizer and using care to elevate the flask so as not to come in contact with it. Vulcanization is accomplished at 60 pounds or 290° F., over a period of one and a half hours, after which it is permitted to cool slowly. The finishing is very similar to that of vulcanite, except that the material is very much harder and there is some danger of chipping.

Porcelite may be used as a material for vulcanite dentures or as an attachment for porcelain teeth to a metal base of any kind. Dentures constructed of this material may be repaired or rebased with little difficulty. Experiments and tests to date indicate that it has many advantages over vulcanite as a base.

The following are some of its apparent advantages:

From the standpoint of esthetics, it approaches the ideal in color and translucency almost defying the closest inspection in the mouth.

It has about one-third less weight than vulcanite dentures of the same bulk.

It may be sterilized in boiling water without change of shape.

It has a great thermal conductivity and in this way promotes the general health of the underlying supporting tissues.

Its hard dense surface is impermeable to saliva and all other fluids.

It is sufficiently strong to withstand the stress of reasonable masticating forces.

It retains its color and translucency in the mouth and becomes tougher with use.

It has no taste or odor.

In short, it approaches in a practical way those ideals of Art which the modern prosthetist has only dared to dream of in the past.

CHAPTER XI.

DIES, COUNTER-DIES AND MOLDING.

By WILLIAM H. TRUEMAN, D.D.S.

REVISED BY

EDWARD KENNEDY, D.D.S.

THE dies and counter-dies used in a dental workroom are reproductions in metal of that portion of a cast of the mouth over which it is desired to adapt a sheet metal plate or appliance by the process of swaging. These dies and counter-dies differ from those used in the industrial arts for a similar purpose in that they serve a temporary purpose only. As they are not designed to produce a large number of duplicates, it is not necessary for them to be made of a wear-resisting metal. They are not required to produce upon the surface of the sheet metal a sharply defined embossed design calling for accurate adaptation of the die to the counter-die. All that is required is an accurate adaptation of the sheet metal to the surface of the cast, and as this surface is a series of easy curves and rounded elevations and depressions, the force of repeated, well directed hammer blows is quite sufficient to accomplish the swaging. This being the case, the size and shape of the bodies of these dies and counter-dies are not restricted by the mechanism of a stamping press, and their construction is thereby very much simplified. If that part of the die technically termed its face is an accurate duplicate of the corresponding portion of the cast, and the die is sufficiently rigid and convenient to handle, its size and shape in other respects are immaterial. The dies are made directly from the model by a process of open mold casting, and are usually made of zinc or Babbitt's metal.

The counter-dies are made by casting over the die a softer metal, and one with a lower fusing point to avoid any liability of union of the two by a partial fusing of the die. The main purpose, however, of using a softer metal for making the counter-die is that it may, by a change in form during the swaging, become slightly larger than the die, and so accommodate itself to the thickness of the sheet metal being swaged. If the die fits into the counter-die exactly and both are made of unyielding metals, they become as it were a punch and matrix, and in the swaging process will cut and tear the sheet metal instead of forming it into the desired shape. In order to avoid this in the sheet metal worker's stamping press, the dies and counter-dies are so constructed that when the press is closed there is sufficient space between them to accommodate the metal used.

The process of constructing dies and counter-dies in the dental laboratory may be briefly stated as follows:

The cast is imbedded in molding-sand contained in an appliance termed a molding-flask. The cast is removed, leaving a space in the sand known as the mold, into which molten metal is poured, producing the desired die. This is now imbedded in molding-sand, leaving only that portion exposed which is to be included in the counter-die. A properly shaped metal ring—a casting- or molding-ring—is placed around the invested die and molten metal poured in the ring to form the counter-die. We shall now consider in detail these various steps, and the materials and appliances used in the process of constructing dental dies and counter-dies.

METALS USED FOR DIES AND COUNTER-DIES.

A metal suitable for making dental dies should possess the following characteristics: It should be hard enough to withstand the force of swaging without marked bruising of its surface; it should be tough and not brittle, so that it will not break in use; it should neither contract nor expand in passing from its fusing temperature to that at which it is to be used; it should be readily fusible in the common heating vessels used in the dental laboratory; and, finally, when molten it should possess sufficient fluidity to permit it to flow freely into small spaces. Of all the available metals, zinc possesses these several properties to the greatest degree, and is, therefore, in general use for making dental dies. Much has been said and written with regard to the undesirable quality of contraction of zinc in cooling. Dr. T. L. Buckingham, by a series of carefully conducted experiments determined that a mold of molten zinc 5 inches in length contracted on cooling $\frac{1}{18}$ inch, or $\frac{1}{90}$ of its length. He estimated that a zinc die 2 inches in width and $2\frac{1}{2}$ inches in length on the surface where the plate is to be swaged, contracted $\frac{1}{45}$ inch in width and $\frac{1}{36}$ inch in length.

Ordinary commercial zinc contains impurities varying greatly in amount and in character which somewhat affect its physical properties and make it unsuitable for dental use. That sold as "the best," however, costing a few cents a pound more, will generally prove satisfactory for making dies.

The importance of properly heating the zinc is not generally appreciated. To obtain the best results the zinc should not be overheated. If it is allowed to become red-hot, it never works quite so well afterward. It oxidizes rapidly at that temperature, and also alloys with the iron of the melting pot. These two conditions combined tend to make it less fluid, and it does not pour as well or make as smooth a die as when it is carefully heated. The various remedies for these conditions found in dental textbooks have proved useless to the writer. The late Mr. Joseph Richards, an expert metallurgist and chemist of Philadelphia, invented and patented a method for restoring oxidized zinc to its normal condition, which is used extensively and with satisfaction. He found that the addition of a very small portion of aluminum to the molten zinc had a very marked deoxidizing effect and quickly restored the zinc to its normal condition. An alloy is made of 9 parts of new zinc and 1 part of aluminum. To the old and oxidized zinc, while it is in a molten condition, approximately one-twenty-fifth of its weight of this alloy is added, and the whole thoroughly stirred. The effect is quickly noticed, the zinc becoming more fluid, and the dirt and oxide separating so that it can be removed. Small amounts of this alloy are added, if needed, until the zinc is in a suitable condition for use, when it may be poured into ingots, the separated dross removed and the metal immediately cast into dies. The aluminum acts as a deoxidizing agent, and the amount necessary is too infinitesimal to have any effect as an alloy. The object in first alloying the aluminum with the zinc is that it may be quickly disseminated throughout the mass.

Cast-iron melting pots are preferable to those made of thin sheet-iron, as they do not so quickly become overheated, and are usually of a more convenient shape. Before being used, the inside of the melting pot should be coated with a paste of whiting and water and well rubbed in. This coating should be renewed several times, until the iron forms a protective coating of its own oxide. Unless this precaution is taken the zinc alloys with or eats into the iron, and in a little while makes a hole, usually where the bottom of the pot joins its sides. It is very important to keep one pot exclusively for the zinc, and another for the lead, and to have them so plainly marked that the mistake of using either for any other purpose is not likely to occur. They should be frequently emptied, and the oxide and dirt which collect at the bottom, and are non-conductors of heat, should be removed. When the molding-sand is sieved, and the scraps of metal found therein returned to their respective pots, those merely supposed to be zinc, or supposed to be lead, had better be discarded.

Zinc is not a desirable addition to lead used for making counter-dies, while zinc contaminated with lead is a very provoking mixture in a dental laboratory. A small amount of lead in zinc forms an alloy that makes the zinc undesirable for use in die making; the larger part of the lead remains as a mere admixture, and the lead, having a lower fusing point and a higher specific gravity, remains fluid after the zinc has set, and has a tendency to settle at some part of the face of the die. When this takes place, if the die remains in the mold until it has cooled below the melting point of lead, the lead forms a soft spot; if the die is removed from the mold at an earlier stage, the still molten lead runs out and leaves a defect in the die; in either case the die is spoiled. The method this suggests for separating the two, *i. e.*, casting the mixed metals in a cone-shape mold and overturning it as soon as the zinc sets, so as to allow molten lead to run out, and which is recommended by metallurgists, is very unsatisfactory in dental laboratory practice.

With ordinary care the metals used for dies and counter-dies add so little to the laboratory expense account that it is economy to renew them when they are found to be in an unsatisfactory state.

Various non-shrinking alloys have been recommended as preferable to zinc for making dental dies, but perhaps the most desirable one is a modification of Babbitt's metal advocated by Dr. L. P. Haskell, of Chicago, of the following formula:

Copper	1 pound.
Antimony	2 pounds.
Tin	8 pounds.

Dr. Haskell contends for this alloy, in addition to its non-shrinking quality, a decided advantage in its low fusing-point. On account of a marked tendency of its components to separate, he directs that after it has been fully fused, avoiding, however, overheating, it should be thoroughly and vigorously stirred with a wooden paddle until it is about to set, but still quite fluid, and then quickly poured into the mold. By this procedure the full advantage of the alloy is secured. If this is not done, the alloy quickly deteriorates and produces rough and unsatisfactory dies. For counter-dies he uses lead alloyed with tin to reduce its fusing-point and increase its hardness. It is only with great care that lead alone can be used for making counter-dies over dies of this alloy. Type metal can be used to good advantage and if old type is used, it is very inexpensive and answers all purposes.

For small dies the various fusible alloys are extensively used. Some operators prefer to make their working casts of these alloys rather than of plaster, because they are stronger and better able to resist wear, or as a time-saver where in special cases the cast is wanted quickly. Some fuse at such low temperatures that with care they may be successfully cast in modeling compound impressions. Melotte's metal, Dee metal, Dialoy and Babbitt's metal are also used. If the die is allowed to become cold and is coated with a separating medium of chalk or whiting, a counter-die can be made of the same material as the die.

Of the non-fusing alloys, silver amalgam and copper amalgam are extensively used as dies for swaging clasps and small capings for crowns. I do not believe, however, that they are practical for swaging saddles. They must be used in a small swaging machine and embedded in modeling compound for support, and rubber used in place of the counter-die. This may be either the unvulcanized base-plate rubber or a plug of semi-hard rubber.

For counter-dies, lead is generally used. These can be supplemented by pure tin counter-dies which are much better than zinc counter-dies as the tin does not cut the gold. Type metal is also used. If the lead counter-dies become enlarged in swaging, it is not always necessary to pour new ones because this does not generally occur until we are near the end of the swaging process, in which event we can take the flat sheets of cottonoid, moisten them, place them in the counter-die and produce a result similar to a hydraulic pressure device. Thin pieces of soft leather, rubber from old hot-water bottles, or even newspaper answer the same purpose, but newspaper separates so easily and is forced out of the counter-die so readily when the swaging is done that it is very dirty.

Lead having a lower fusing-point than zinc, does not oxidize quite so rapidly, and is not so seriously injured by overheating, nor is it quite so sensitive to admixtures. While accidental addition of a little zinc is no improvement, it is not a serious detriment. Various expedients have been recommended to prevent the lead from oxidizing, or to reduce the oxide to a metallic state. The ordinary pink paraffin wax scrap left over from waxing up dentures can be thrown on the molten lead and allowed to burn. This separates the dross, which rises to the surface and most of it is easily removed. The little which is left should be scraped off with the molding trowel just before the lead is poured. The lead should never be allowed to become overheated, as this causes oxidation. This is important but not so important as avoiding the overheating of the zinc.

TOOLS AND APPLIANCES.

The following tools and appliances are desirable for making dies and counter-dies:

1. **Molding Table.**—The writer has a molding table designed by Dr. A. DeWitt Gritman made of a sheet of iron $\frac{1}{4}$ inch thick, 30 inches wide and 4 feet long supported on legs made of pipe and pipe fittings. The table is about 30 inches in height. On top of this is a wooden frame and cover to hold the molding sand. When the cover is in place, it makes a very convenient table, economizing space. The table is provided with drawers for holding the molding materials. At one end, outside of the wooden frame, is enough space for a gas stove with a furnace cover which is used for melting the zinc, lead and Babbitt's metal (Figs. 412 and 413).

2. **Sieve.**—This should have twelve meshes to the inch and to avoid rusting, should be made of brass wire, with wood or tin sides.

3. **Flasks.**—These are iron boxes in which the molds are made. The iron casting-rings sold in the dental depots in nests containing four or five sizes are inexpensive (Fig. 414). These rings are also used for making counter-dies. A more practical set designed by Dr. A. DeWitt Gritman and made by Bellfield & Co., can be procured through the dental depots. These provide an easy way of making progressive counter-dies, which are very necessary to use when swaging full dentures, and which will be described later in this chapter. The casting rings are pieces of cast iron or wrought iron drain pipe $2\frac{1}{2}$ inches high and 5, $4\frac{1}{2}$, 4 and $3\frac{1}{2}$ inches in diameter. The rings for the base of the dies and counter-dies are cast iron made in the shape of a

truncated cone. The top and bottom edges are turned smooth and of the same diameter at their base as the casting rings. Four small truncated cones, $\frac{1}{2}$ inch in height are used to confine the sand when making progressive counter-dies (Fig. 415).

4. **Trowels.**—One or more small trowels such as are used in iron and brass foundries (Fig. 416).

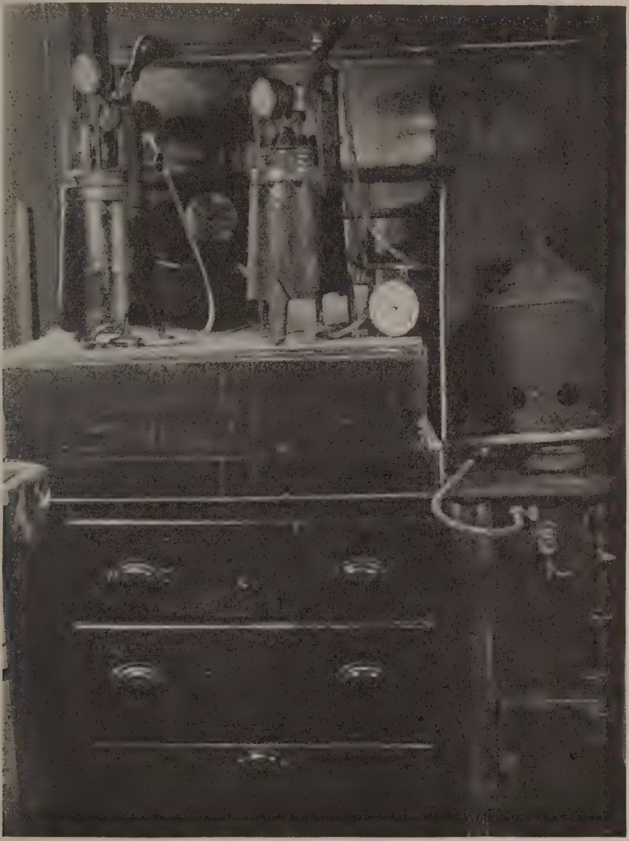

Fig. 412.—Molding table with vulcanizers on top.

5. **Small Brush.**—A small brush for brushing the sand from the model or the die in molding and making counter-dies. A small flat paint brush $\frac{3}{4}$ inch wide with a long handle is preferable and can be bought at the dental supply houses.

6. **Sand Packer.**—An instrument should be provided for packing the sand. One can readily be made of a round stick about $1\frac{1}{2}$ inches in diameter cut wedge-shaped at one end and flattened at the other (Fig. 417). It should be about 12 inches long and can also be used as

a straight-edge in smoothing off the sand when the flask is full. The wall-paper scraper shown in Fig. 416 suggested by Dr. Gritman, is also useful for this purpose.

7. **Rubber Tube.**—A rubber tube 6 or 8 inches long and $\frac{1}{4}$ inch in diameter is used to blow out sand that has fallen into the deeper portion of the mold.

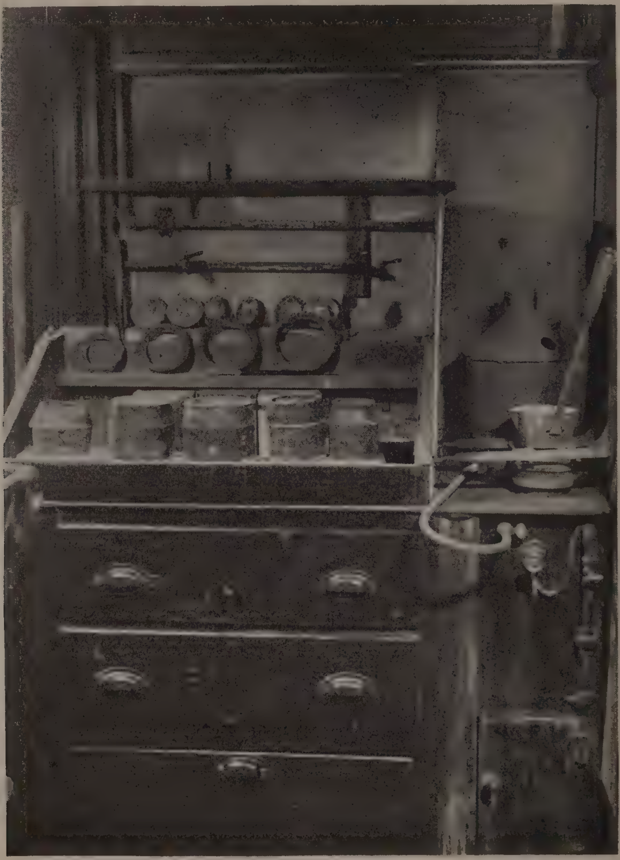

FIG. 413.—Molding table open showing instruments, rings and dies and counter-dies.

8. In addition to these, a camel's-hair pencil, a small hammer, a small mallet and a small cold chisel may be provided.

9. **Lifter.**—An instrument for lifting the cast from the sand may be (Fig. 418) made by soldering a small piece of brass tubing onto a brass crucible-former an inch in diameter. This is placed upon the model and stuck with wax. The small hammer (Fig. 418) is used to jar the cast slightly while it is pulled in an upward direction by the upright brass rod in removing the cast from the sand. At no time should an

attempt be made to drive a sharp instrument into the cast to act as a handle for removing it as there is liability of splitting the cast and distorting the molding sand.

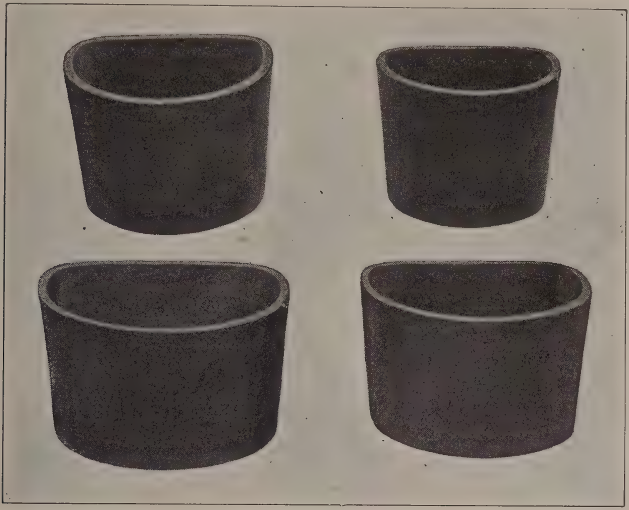

FIG. 414.—Set of cast-iron molding rings.

10. **Melting Pots.**—The melting pots should be made of cast iron and marked "for lead," "for zinc," "for Babbitt's" (Fig. 419), and no pot should ever be used for melting any metal other than that for which it is marked, or we are liable to mix metals. The handle should be made of wrought iron terminating in a wooden handle and should be so made that the wooden handle will not separate from the iron portion when we lift the pot from the fire. I have seen two such accidents

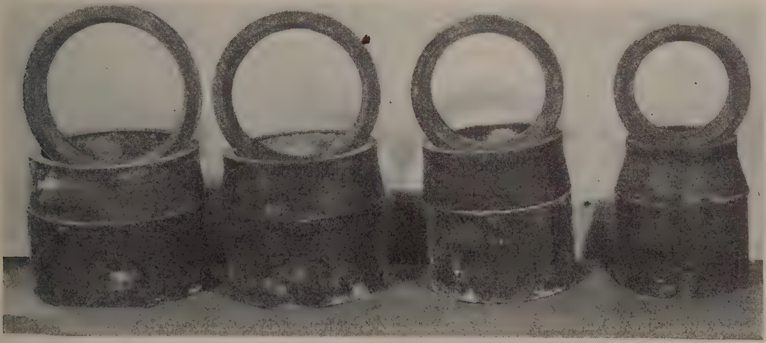

FIG. 415.—Gritman rings for dies and progressive counter-dies.

which caused quite severe burns. Do not buy a cheap melting pot or one with a handle which is insecure or made of cast iron.

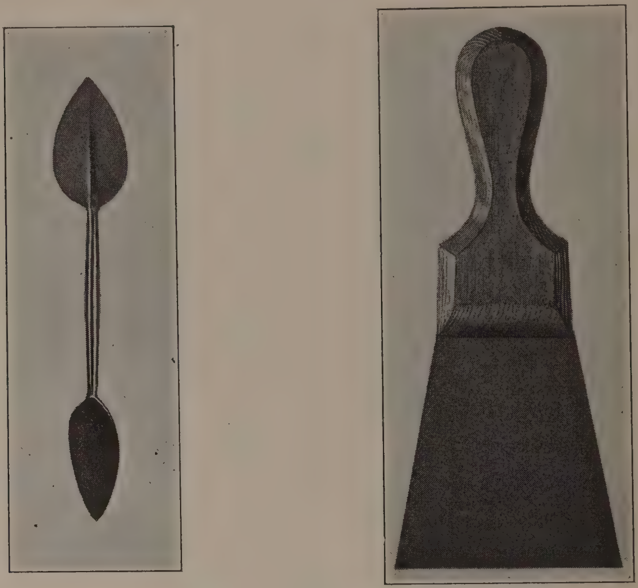

Fig. 416.—Trowel and scraper useful in making molds.

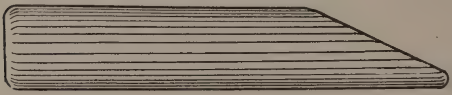

Fig. 417.—Sketch of packing tool.

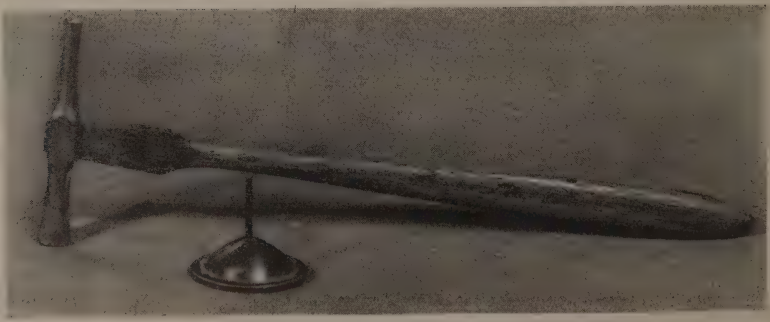

Fig. 418.—Lifter and hammer.

11. A fine steel wire or a very fine steel knitting needle should be provided for passing through the sand mold if the sand is too damp

and shows a tendency to cause the metal to bubble. I have successfully used for this purpose the saws from the bracket frame and they answer the purpose very well.

12. **Separating Media.**—Lycopodium, soap-stone or even talcum powder make good separating media to prevent the sand from sticking to the model. They should be placed in a box with a sifter top for convenience.

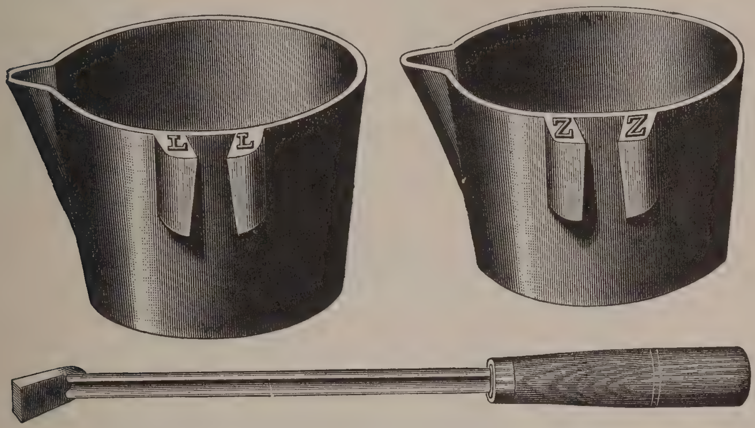

Fig. 419.—Melting pots for zinc and lead, with handle.

MOLDING-SAND.

The sand used for molding should be of sufficiently fine grain to give a smooth surface to metals poured over it, and yet possess sufficient porosity when packed in a molding-ring to permit the escape of steam formed when molten metal is poured into a moist mold, and should form a mass of sufficient coherence to maintain a given form and to permit the withdrawal of a properly shaped cast from it without fracture.

Formerly several varieties of sand were used in the dental laboratory for making molds. The first and oldest was iron-founders' black sand. Another was brass-founders' brown sand. These had the disadvantage of requiring a mixture of water at the time of using, with the consequent danger of bubbling, or the other alternative of drying out the mold before pouring the metal, which required a great deal of time. Within a few years several substitutes for molding sand have been offered by the dental supply houses. Among the first was one suggested by Dr. A. DeWitt Gritman known as "calcar." It was made by mixing 8 ounces of glycerin with 8 quarts of the finest flour marble dust and passing the mixture through a twelve-mesh sieve on three successive days. Each day the sand is packed hard in a tin box to allow the glycerin to be absorbed by the marble dust. The glycerin is hydroscopic and absorbs moisture from the air. For the busy practioner it is not worth while to make it or to use sand that requires mixing with water, as there is always the liability of steam forming and spoiling the die.

PREPARING THE MODEL.

Apart from the manipulation which a plaster model of the mouth requires to impart to it a desirable size and shape, more or less preparation is necessary preparatory to molding and casting the die. First, the outline of the plate or appliance for the construction of which the die is required and the position of the relief, clasps, etc., must be accurately traced on the model, in order to know how much of the surface of the model should be included in the metallic die. The model should be level, that is, its face and its bottom should be parallel whenever possible; if not, they should be made so by adding to or cutting away from the bottom.

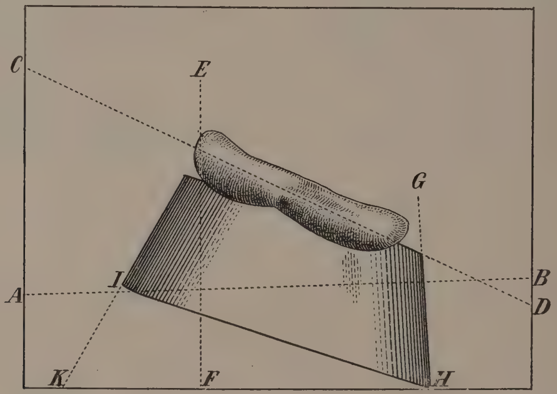

FIG. 420.—Diagram showing method of tilting model to avoid undercut.

We are now speaking of the ideal condition. It is absolutely essential that the labial face of the ridge be parallel with the back of the base. If we look at Fig. 420 the line *E F* drawn parallel with the labial face of the ridge, must be parallel with line *G H* drawn parallel with the back of the base, and this is done by cutting the base of the cast *A B* at right angles to the line *E F* and *G H*. If this makes the model too thin, it will be necessary to add sufficient plaster to the base, as represented by the triangle *H I K*, to bring it into this position. If this cannot be done, then we must resort to coring, which will be described in a later paragraph. It is preferable to make the base by adding plaster after the model is poured as it is a simple matter to remove this base from the model after we have obtained the dies and counter-dies. It makes it much easier to place it upon an articulator, especially one of the anatomical type.

In applying a base to a model, the plaster should be built up on a glass slab and be of sufficient thickness to prevent running, and the model, which has been previously soaked in water, is placed in the position indicated in the diagram (Fig. 420). When the plaster has hardened sufficiently to allow being worked, it should be smoothed up approximately to the correct degree and set aside to harden. It is then dressed down with a rasp, followed by coarse sandpaper and finally with fine sandpaper.

It is essential that the base should be absolutely flat on the bottom, for if it is not flat, it will cause the model to rock when packing the sand and a distorted die will be the result.

As a matter of neatness and convenience, the model should not be much larger than is actually required. About $\frac{1}{8}$ to $\frac{1}{4}$ inch margin at the posterior line of the plate in full dentures, and the width of at least one tooth in partial cases and regulating appliances, is usually sufficient.

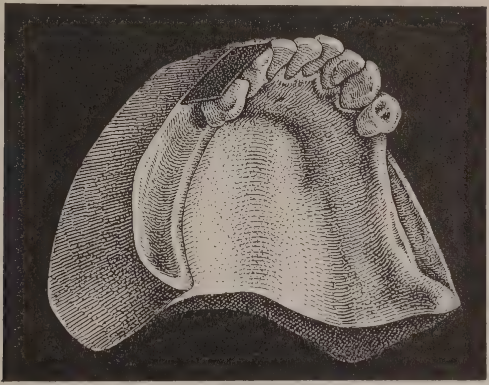

Fig. 421.—Partial lower cast prepared as model for a die.

The sides should slope slightly so that it will readily leave the sand. Fill up all acute undercuts not needed on the die that may tend to prevent the model from freely leaving the sand, although they may be at points distant from the face of the model. If they are not essential parts of the future cast, fill them up with either plaster or wax; if they are essential, enlarge without deepening them and without encroaching upon any portion of the cast to be covered by the plate, and give them a rounded form. A marked undercut due to an overhanging alveolar ridge, or at the lingual aspect of lower cases, may often be accurately reproduced in the die if so rounded as to leave space for a larger body of sand (Fig. 421).

All of the rugæ on the cast should be carefully built up with pink paraffin wax as these projections have to take the brunt of the swaging, for there is a tendency for the zinc die to flatten out under the swaging process. If this happens, soreness will occur on the rugæ and it will be impossible to relieve it without cutting into the gold. As there is only a thickness of 26 gauge in the thickest plates, we are very likely to cut through the plate and destroy it. The incisive pad should be relieved particularly, and any thin edges on the upper or lower ridge. In partial dentures, it is a good plan to relieve the gingival margin for a distance of $\frac{1}{4}$ inch back of the teeth, so that the pressure will be kept off the delicate tissues around the teeth. The thickness of the relief varies from about the thickness of 26- to 24-gauge wax. Formerly it was the custom to make a vacuum-chamber. This produced suction and prevented rocking of the denture by raising it from the central hard spot along the median raphe. The suction produced by the vacuum-chamber was only temporary, but it served its purpose until the patient became accustomed to wearing the denture. After a short while, however, mucous tissue was drawn down into the suction chamber and became very much irritated. Dr. Semken of the Crocker Foundation for Cancer Research has told me that about 2 per cent of the cancers of the mouth can be traced to faulty bridge and denture work, and he believes that almost all of the cancers in the upper mouth are caused by pressure of the plate on the median line.

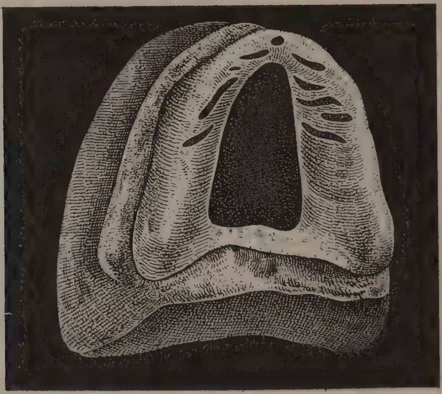

FIG. 422.—Full upper cast prepared as model for die.

The hard area must be relieved, but there must be no sharp edges to cause pressure spots to develop. This is done by running a relief anteriorly from the incisal pad to the posterior border of the hard spot and extending it out on each side until we reach semi-soft tissue. A piece of pink paraffin base wax is heated and placed over the outline. The outline, if sufficiently heavy, can be seen through the paraffin wax and the wax trimmed with a sharp knife. This wax relief is attached to the model with either sticky wax or shellac, and the edges of the wax trimmed down until there is no perceptible line of demarcation (Fig. 422). The wax can be smoothed up with chloroform and when the model is dry, a coating of thin shellac is applied to cover the entire surface of the model with the exception of the bottom of the base. After this is sufficiently dry, a coating of thin sandarac varnish is applied, and the model placed in a cool dry place to allow it to thoroughly harden. It should then be rubbed with lycopodium, soap-stone or talcum powder and any surplus removed with a camel's-hair brush.

Model for Partial Cases.—The preparation of models for partial cases is complicated by the presence of the teeth. In some cases it is not a serious matter, but in others it makes it quite difficult. If the teeth lean or are so shaped as to impair the accuracy of the mold, we endeavor to correct it by changing the shape of the teeth or the spaces between them by adding wax. If the model is held at arm's length in front of one eye, closing the other, we should be able to see all surfaces excepting the bottom of the base. Then we know whether or not it can be readily drawn from the mold.

If a model is made from a modeling compound impression, using the proper technic, as pointed out by the author in the *Items of Interest*, May, 1925, the drag on the palatal surface and that between the teeth will already have been taken care of and it is only necessary to fill out the undercuts on the buccal and the labial surfaces. When the casts for partial cases are poured, the teeth standing alone should be strengthened by placing little brass brads $\frac{1}{2}$ inch long with the points down in the teeth and the heads in the base of the model. Brass brads are used because they are much easier to saw through, as it is often necessary to saw these teeth off when obtaining the dies. The best way to saw these teeth off is with a very fine saw in a saw frame. Beginning on the lingual side, saw through three-quarters of the way to the labial or buccal surfaces, then by pressing with the fingers, break off the rest of the tooth, and carefully put this aside until the die is made The rough surface on the model is covered with wax and after having finished making the die, this wax is lifted off and the tooth cemented back into its proper position. The rough surface acts as a key-mark to show the proper position.

MAKING THE MOLDS.

After the varnish is thoroughly dried on the model and it has been rubbed with soap-stone (and this is best done by rubbing it on with the fingers and removing any surplus with a soft brush), a light dusting of lycopodium is applied on the model.

Place the model on the bench with the back toward you and its face uppermost; place over it the flask, so that it occupies a central position, selecting a flask sufficiently large to allow $\frac{1}{2}$ inch thickness of sand on all sides of the model. Now take a handful of sand and sift it through the sieve upon the model, making it as fine as possible, until the model is entirely covered; then with the fingers press it down firmly, packing it especially well between the sides of the flask and the model. After the model is covered, the sand may be added more rapidly until the flask is full. Press the sand down firmly and evenly with a packing tool or the handle of the scraper shown in Fig. 416. If the sand is not packed firmly enough, the mold will be rough, the model will be inclined to "drag," that is, it will not leave the sand freely, and the sand will be liable to be displaced when the metal is poured in. If it is packed too solidly, the vapor caused by the hot metal will not be able to escape through the sand, and there is danger of the die being injured by the vapor bubbling through the metal. The desirable mean between these two extremes can only be learned by experience. Wire drawn through the sand mold at its highest point will allow escape of vapor.

When the flask is full, level off the surface with the side of the packing tool previously mentioned, or with a suitably shaped trowel, and, lifting the flask with its contents, brush away the sand from that part of the bench, and turning the flask over, carefully lay it down with the bottom of the model up. Next run the point of the scraper, held at an angle of about 40 degrees, all round the model, so as to make a bevel in the sand $\frac{1}{16}$ inch deep and from $\frac{1}{4}$ to $\frac{1}{2}$ inch wide. Brush off the sand the point of the scraper has loosened; or the flask may be raised and the sand thrown off by a quick motion, care being taken that the model is not disturbed. This is done by holding the flask between the thumb and the third, fourth and fifth fingers, the first finger being placed upon the model.

To remove the model from the sand requires considerable skill. The old practice of driving an instrument into the model should never be resorted to, as it is very liable to split the model and at the same time drive the model down and disturb the buccal and labial surfaces of the future die. The better practice is to take a sprue former, and solder a brass wire into the hole of the crucible former. This can be attached to the model by means of sticky wax. Holding the wire with one hand, tap lightly on the model with a small hammer. These instruments are shown in Fig. 418. As we tap, we pull upon the crucible former and when we feel the model loosening, we tilt it and draw it in the direction of the least resistance. This jarring serves another useful purpose; if the sand of the mold is broken by an undercut or a leaning tooth, it may be dislodged from the model and fall into its proper position or nearly so, where it can be adjusted with a camel's-hair pencil and securely held in place by letting a drop of water from the camel's-hair pencil fall on the line of fracture. When this has been done, it will not do to invert the mold. Any particles of sand that have fallen in can be removed by touching with moistened camel's-hair pencil or by carefully blowing them out with the aid of a piece of rubber tubing.

Extra care will be necessary in pouring the metal to avoid displacing these fractured portions of the mold. Instead of filling the mold at once, pour in enough metal to almost cover the fractured portion, then stop a moment to let the metal approach the setting-point, then add a little more, just to cover it, and in a few moments the operation may be completed. If this precaution is not observed, in all probability the broken portion will be floated from position and the die spoiled.

Having removed the model, observe if any sand clings to it on those portions included within the line of the proposed denture. If so, before disturbing it, examine the mold; if that is not badly broken, proceed to consolidate the loose sand around the edge of the mold with the fingers, rounding the bevel made with the point, and being careful while doing so that no sand falls in. This accomplished, the flask may be carefully lifted, and can in that way be more conveniently examined. First look for any fractured portions that may be restored, and make them secure; then note whether the sand brought out by the model seriously impairs its accuracy; if it should be at points readily corrected in the die, and the mold is otherwise satisfactory, it may be accepted. If, however, this is not the case, an effort may be made to dislodge the sand from the model without breaking it up, and adjusting it to place in the mold. If these expedients fail, the mold should be rejected. Before proceeding to a second trial, note if any permissible changes in the model will overcome the difficulty. It is quite frequently the case that the first effort fails, and yet it may suggest some little change in the manipulation that will make a subsequent effort successful without the necessity of any change in the model. A delicate sense of touch to quickly detect the point where the removal of the model from the mold is resisted, and judgment in overcoming the resistance, should be carefully cultivated. In some cases, as for instance, a model of a partial upper denture with a deep vault and prominent rugæ, it is necessary to press the model forward and at the same time lift it from the mold by raising the front first; a similar movement will best serve for a model of a full lower denture with a marked undercut at its lingual aspect.

In most cases two zinc dies are required and one Babbitt's metal die. Therefore, three molds must be made. It not unfrequently happens that repeated efforts must be made before satisfactory molds are secured, and now and again one must be satisfied with the best that can be obtained and depend upon correcting the defects of the mold by carving the die cast in it. It may be a question whether it is best to do this or to spend a great deal more time in the effort to secure a better mold by the troublesome process of making cores. After satisfactory molds have been made, they should be laid aside where they will not be injured before the metal is poured in. It should be remembered that a sand mold is quite friable, and becomes more so if allowed to dry. It is, therefore, prudent to do the casting as soon as possible.

In these difficult cases, as the labor of pouring the metal in the mold is but trifling, it is well to make several dies and select the best two.

CORE MOLDING.

In cases where it is otherwise impossible to obtain a sufficiently accurate sand mold owing to the presence of sharp undercuts, leaning teeth, etc., recourse is had to core molding. Cores are temporary additions made to the model which so change its shape at the points where difficulty exists that an accurate sand mold can be made. These cores should be in position on the model when the sand mold is made; they are then removed and placed in the impressions they have made in the sand and become part of the mold. They are made of plaster that can be molded to the model, has sufficient strength to bear the necessary handling, and will not interfere with the process of casting. Plaster of Paris, to which has been added about one-half of its bulk of pulverized asbestos (No. 90, Johns-Manville Co.), or any similar substance that will mix with the plaster and enable it to bear a red heat without cracking or shrinking.

The investment materials recently introduced are admirable for this purpose. In order to avoid bubbling, the cores must be thoroughly dried or baked before the molten metal is brought in contact with them, and as the sand molds must be used very soon after they are made, the core material must admit of this being done quickly without change of bulk or shape. The drying is conveniently done in an electric or gas drying oven, or by means of the blowpipe, care being taken, however, not to burn off or destroy the sharp edges. This must be done after the mold has been made, as the baking makes the cores friable and easily broken; or if this is avoided by careful handling, when hot they will melt the varnish and stick to the model, also if the cores are long in contact with the damp sand, they may absorb from it sufficient moisture to cause bubbling as freely as though they had not been baked.

The usual precaution of first preparing the cast by oiling, so that the material of the core will not unite with it, must be observed. While cores must extend as far as needed to facilitate molding, it is desirable to keep them as small as is consistent with strength and their ready replacement, and to so shape them that they will leave in the sand an impression that will hold them accurately and securely in place when the metal is poured into the mold. As these cores when baked are light as compared with the metal, unless securely held, they are apt to float out of position when the casting is made. To prevent this, the metal should be poured in the mold slowly, a little at a time, so that the first portion will have commenced to set and assist in holding the core in place before the mass of metal is added, and yet this must not be done so deliberately that the various portions do not unite as thoroughly as though the pouring were continuous. When pouring, always rest the point of the molding trowel against the core to hold it in place until the metal has covered it.

Cores are needed for models of edentulous upper jaws more often than for those of the lower jaws because of the frequent occurrence in the upper jaws of a marked overhanging ridge. In these cases it is usually best, and is usually practicable, to make one large core to embrace the front of the model as far as the overhang extends, as shown in Fig. 423. Occasionally, however, the depression of both sides may be so marked that it is necessary to divide the core at the median line. Models of lower edentulous jaws with a marked inward lean of the ridge may require cores to secure accuracy of the lingual aspect. In such cases it is usually best to make the core in two sections, shaped as shown in Figs. 424 and 425, so as to permit of their removal without injury to the cast. The conditions calling for cores in partial cases of either jaw are so varied that only general instructions for making them can be given. They should be so arranged that they can be readily removed without injury to the cast; they should be as small as is consistent with the correction of the trouble requiring their use and their secure adjustment in the mold. Thin edges of either the core or the sand mold are to be avoided, and the general shape should be such that they can be accurately replaced in the mold.

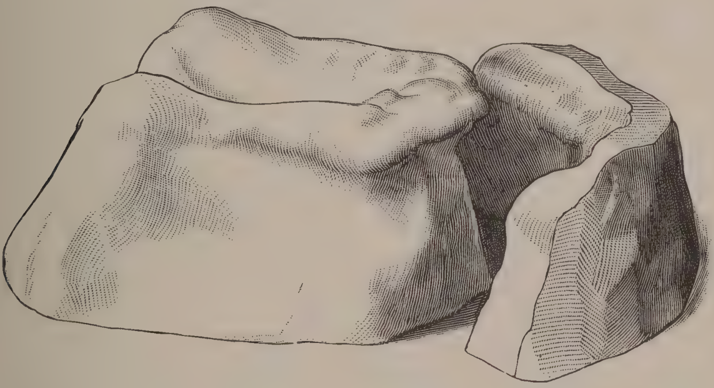

Fig. 423.—Full upper model with alveolar undercut, showing form of core to fill in undercut.

Now and again, especially with models for partial lower cases with leaning teeth, it is expedient to allow the core to take the form of an impression taken in sections. The separate portions accurately united and held together with adhesive wax applied on the inside, form a mold to be imbedded in a mass of the same material of which they are made. This is thoroughly dried and the metal poured in. For convenience, just before pouring the metal, this mold may be imbedded in molding-sand, and a casting-ring placed around it to give to the die the proper size and shape.

At times, it is better in such cases to take a plaster impression of the model in sections, from which to make a new cast of that portion to be covered by the plate, and from this to remove the teeth. This simplifies very much the making of the dies. The plate is made on this new model, the portion extending over the teeth being afterward added in the form of soldered-on collars, made and adjusted to the original model.

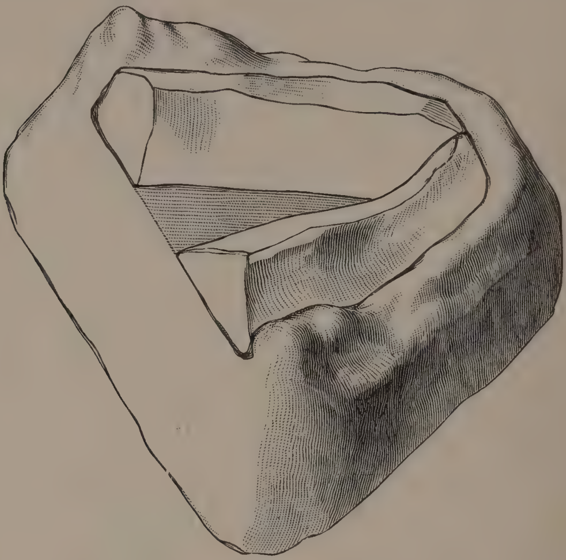

Fig. 424.—Full lower model with lingual alveolar undercut and core in two pieces in place.

In some cases of marked leaning teeth that are very firm in position, exact accuracy is not required, as an accurately fitting plate cannot be forced over them.

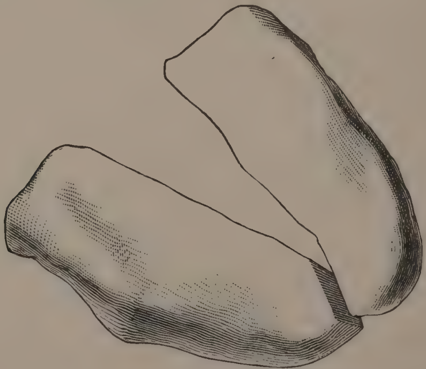

Fig. 425.—Underview of two-piece core for full lower model shown in Fig. 424.

The actual manipulation of cores differs in nowise from the usual plaster working of the dental laboratory. The plaster should be applied to the model neatly, and confined to that portion requiring a core. After the core has been poured upon the model and has sufficiently hardened, it should be cut to correct shape without removing it from the model. Then it should be rubbed with soap-stone or talcum powder and the next core poured against it. Cores always should be interlocking as they hold each other in place. They should never be in large sections, as they are liable to become distorted. If the entire buccal and labial surfaces of the model need to be covered, the core should be broken up into three if not four sections.

CASTING THE DIES.

When ready to begin casting, the molds are arranged on the casting bench in convenient positions for pouring the metal. Suitable casting-rings should be close at hand, together with a supply of molding sand with which to close any openings between the molds and the casting-rings through which the metal might escape. The metal having been fused in the melting pot, is brought to the bench. With an iron spoon, or a molder's trowel, remove any oxide or dirt floating on the surface of the metal, especially from near the lip of the pot. If the metal is very hot, it is best to delay pouring until it has somewhat cooled. It is desirable that the metal shall quickly set when poured into the mold, so that the principal shrinkage shall take place in the center of the mass. Pour the metal in a gentle stream into the mold at one of its back corners, holding the lip of the melting pot as close as possible to the sand and protecting the side by putting the molding trowel close to it so that the force of the blow of the falling metal will be distributed. Babbitt's metal should be poured when some of it is still unmelted in the pot. It should be stirred with a fine stick and if the stick catches fire, it is too hot and should be allowed to cool.

If the metal is poured in from a height, or in too heavy a stream, the sand of the mold is liable to be disturbed and the die thereby rendered rough and inaccurate; on the other hand, the pouring must be done quickly enough for the metal to flow into position before being chilled. When the sand mold is filled, if the die is not thick enough, immediately place over it a casting-ring, the large end down, pressing it gently, and continue pouring until enough metal has been added.

If bubbling occurs, stop pouring for a few moments when the mold is about half full, and just before the metal in the mold begins to set, pour in more metal, holding the melting pot at a little height over the mold. If the bubbling has been slight this will frequently save the die; if, however, it has been quite marked the die is usually worthless. This can always be prevented by passing a fine wire or saw from the saw frame through the sand mold. It is time saved to have the melting pot large enough to hold sufficient metal for several dies, and to pour several from the one melting.

When the dies are fully set, turn them out of the mold, and examine their condition. Zinc, when quite hot, is far easier to work than when cold; expert workmen take advantage of this by cutting off the teeth of dies for partial cases with a pair of large wire cutters, a cold chisel, or hack-saw, and with file and gravers roughly correct any inaccuracies that may be noted. This can readily be done while the die is far too hot to handle by holding it in the large bench vise, and much time and labor are saved. When cold, the die is critically examined, and any corrections needed before making the counter-die are now made. If for a partial plate, the teeth may now be cut from the least desirable die, or this may be deferred until after the counter-die has been made.

Inaccuracies due to imperfect molding on that portion of the die to be covered by the plate will also need attention. Spaces between teeth, undercuts, and the margin of relief should be carefully compared with the model, and made to correspond as nearly as possible. In making these corrections the cold chisel may be used where much has to be removed; as a rule, however, the files and gravers, and occasionally a bur in the dental engine, will prove effective tools. It is just as important not to remove too much as it is to remove enough, and very important not to encroach upon any portion of the die that does not need correction.

COUNTER-DIES.

In former times the dentist was in the habit of making counter-dies to cover the entire outline of the plate and sometimes more than the entire outline. This made it very difficult to swage a plate without wrinkling the metal. Dr. Gritman produced a series of rings which enable us by a simple process to make counter-dies which are progressive in relation to the area which they cover. The first counter-die covers only the palatal surface in the upper. The second counter-die of the upper extends over the ridge and about one-third down. The third counter-die extends just to the plate outline. This is sufficient, because, in swaging, the die would be driven into the counter-die a little farther and would extend a little beyond the plate outline.

In the lower, if the ridge is high, we make four progressive counter-dies. The first extending just to the top of the ridge; the second half of the way down; the third and fourth to the plate outline. As a great many lower jaws are very flat, this necessity is not as great as in the upper jaw. In partial cases the same thing holds true, especially where the metal plate extends into open spaces between the teeth. These little tongues should be gradually swaged down in three successive stages.

No one who has used the progressive counter-dies would ever go back to the old method. If we stop for a moment to think that the function of the counter-die is to drive the metal we are swaging onto the die, we realize that it is a waste of energy to have to displace metal in the counter-die which is beyond the area of the plate outline. The progressive counter-dies also obviate the trouble that ensues in getting the wrinkles out of the swaged metal that usually occurred in the use of the old method.

There are four sizes of rings for making the counter-dies, and four narrow rings which are used to confine the sand which is packed around the die. When we are pouring the counter-die, we take the largest ring and place the die in it, packing sand around it. On top of this we place the largest intermediate or narrow ring as shown in Fig. 415 and pack sand around it up to the die. Then we place the next smaller intermediate ring and pack sand around that, and if necessary the next smaller one and even the fourth if necessary. The object of using these several rings is to allow the building up of the sand so that it comes up even with the top of the ridge. The sand which is in the palatal portion of the die is brushed out, and the sand is smoothed down even with the intermediate rings. In a case where we are using a zinc die, it is preferable to do this while the die is still slightly hot, as it bakes the sand around the die and gives a much smoother surface to the lead counter-die. Do not attempt this on a Babbitt's metal die. Also it is not advisable to pour counter-dies against it, as they may stick to the die. Use the zinc die which is a replica of the Babbitt die for this purpose. As we do the heavy swaging on the zinc die and the final swaging on the Babbitt die, the counter-die that fits one will fit the other.

Now one of the other counter-die rings is placed on top of the last intermediate ring and the lead poured into it. As soon as the metal has hardened, the trowel is placed between the counter-die ring and the last intermediate ring and the latter lifted off. The sand which is hard by this time, can be cut down with a trowel and the pieces brushed or blown away. The counter-die ring of suitable size is selected that best fits the case. We try to have the counter-die extend at least from $\frac{3}{4}$ to 1 inch beyond the outside of the die. The metal is then poured into this one, and the process is repeated. This time it will be necessary to remove the first intermediate ring and the sand again cut down to the point desired, preferably to the plate outline.

Two counter-dies are always poured to the full plate outline, and one is retained for doing the final swaging on the Babbitt's metal die. The third counter-die will fit the Babbitt's metal die very accurately if one blow of the hammer is delivered on the Babbitt's metal die before we begin swaging with this last counter-die. As the counter-die and the intermediate rings are turned with a flat surface, we do not have leaking of the metal of the counter-die between these, as almost always occurred in the old method of just building sand around the die without confining it in an iron ring and then forcing a casting ring into it to hold the metal of the counter-die.

Do not fill the counter-die rings to overflowing, as it will be difficult to remove the counter-die from the ring unless we use a cold chisel and this will mar the smooth surface and invite leaks of metal in future operations. Counter-dies can be cooled in water immediately upon pouring but care must be taken to protect the hands and eyes as the hot water splashing from the dies produces very nasty burns. A Babbitt's metal die or a zinc die should not be put in water while hot as this cracks it and spoils the die when we start swaging on it.

LOW-FUSING ALLOY DIES AND COUNTER-DIES FOR SPECIAL USE.

Now and again, the so-called fusible metals can be advantageously used for making dies and counter-dies. Dies for small plates to be made of thin, soft, high carat gold, may be made of these low-fusing alloys cast into plaster or Moldine impressions, saving not only time, but the expense and trouble of melting the less fusible metals. In repair work, the low-fusing alloy may be cast upon a gold, silver or vulcanite plate with perfect safety. A low-fusing alloy counter-die may, in some cases, be cast upon a plaster cast direct; making the counter-die first and the die being made by using the counter-die as an impression.

While dies and counter-dies of low-fusing alloys are not hard enough for serious work in swaging, and are too brittle to withstand heavy hammer blows, they, nevertheless, serve a useful purpose for forming soft and pliable metals. Instead of using a hammer, the swaging may be done between the jaws of the bench vise, or in the Pryor swager. To get the best results with low-fusing alloys they should not be overheated, nor yet poured when quite fluid. Just before setting they assume a plastic condition, and then make a harder and smoother die. In order to prevent the two dies from uniting when both are made of low-fusing alloy, the first cast should be quite cold, and the alloy used in making the second casting should be as cool as it can be poured. Painting the surface with whiting is helpful but unnecessary, if proper care is observed. The writer has successfully used a method described by Dr. Tench in the August, 1926 issue of the *Journal of the American Dental Laboratory Association,* and quoted *in extenso* in Chapter XII.

CHAPTER XII.

SWAGED METAL PLATES.

By EDWARD KENNEDY, D.D.S.

The swaged metal plate[1] has many advantages over the cast plate, although for some years it has seemed as though swaging may become a lost art. It is thinner than a cast plate of the same tensile strength and has the advantage that if it does not fit tightly in any one spot it can be bent or reswaged. It is denser and does not present any porosity as does the cast plate. It can be made of various alloys and various combinations of alloys to suit the case in hand.

Swaged plates are sometimes made of aluminum, of silver and of gold in the form of its various alloys with copper, silver and platinum, each of which imparts a different character to the plate. They are also made of platinum, iridio-platinum and palladium and silver. The last-named alloy is proving very satisfactory. Recently the writer has had under observation some plates made of stainless steel, which are also satisfactory, although they are difficult to swage.

DIE AND COUNTER-DIE METHOD OF SWAGING.

In swaging a plate it is necessary to provide the proper dies and counter-dies, or a device with which to press the plate.

With the die and counter-die method it is necessary to have a good zinc die and a good Babbitt's metal die and four or five counter-dies. The zinc die is used to do the heavy swaging.

As there is a certain amount of contraction in the zinc die which may prove of advantage in a soft mouth, the plate should be tried in the mouth as it is being made upon the zinc die. If it fits, no further swaging is necessary. If it does not fit, it is swaged upon the Babbitt's metal die, which exhibits no contraction or expansion, when the plate will generally be found to fit, especially if the tissues of the mouth are hard.

The dies should be examined to see that there are no imperfections upon them, and if there are any, they should be corrected by grinding them off, if they consist of raised points upon the surface of the die. If the imperfections are depressions the only thing to be done is to remake the die. If one is making the old-fashioned plate with an air-chamber in it, the raised surface over which the air-chamber fits should be ground and polished.

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[1] By the term "plate" is meant that portion of the denture which rests against the gum. It is also called the base.

The counter-dies which are made of lead or type metal, preferably lead, should be of the progressive variety: The first one covering the palatal surface only, the second extending just beyond the summit of the alveolar ridge, the third extending part way down the ridge and the fourth one extending to the plate outline but not beyond it. The fourth counter-die should be in duplicate so as to have an extra counter-die in case it becomes necessary to swage on the Babbitt's metal die.

In partial cases the first counter-die should cover the palatal surface only. The second should cover the palatal surface and that surface which is just over the ridge. The last one should extend to the plate outline. The type metal counter-dies are only necessary where there is a very deep arch or where clasp metal is being swaged, which is very stiff and hard to swage.

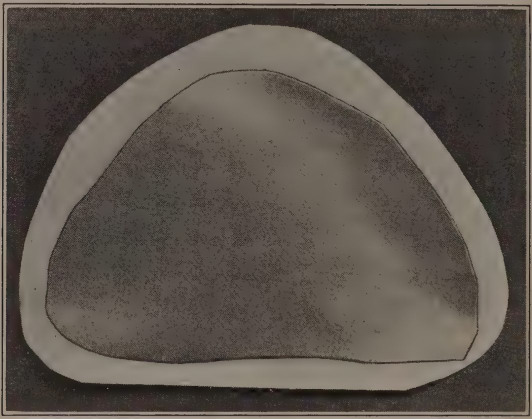

Fig. 426.—Tin-foil pattern of a full upper denture flattened out and all large wrinkles removed; placed on stiff writing paper which is cut ¼ inch larger all around.

PATTERNS.

A pattern of the metal to be used for the plate should be made of thick tin-foil. If absolute accuracy is wanted, the tin-foil should be of the same gauge as the plate. It should be placed upon the die and burnished in place with the fingers assisted by a rubber in the end of a lead pencil. The work should be done upon the die and not upon the model, as there is danger of marring the waxing on the model.

When the pattern is trimmed to the plate outline (Fig. 427, *A*), it is flattened out and smoothed so it has no wrinkles (Fig. 426). It is then placed on stiff white paper and outlined with a lead pencil (Fig. 426) ¼ inch larger all around to give sufficient surplus for swaging. If a relief chamber or strengtheners are being made extra, patterns are cut for these (Figs. 427, *A*, *B*, *C;* Fig. 428 and Fig. 429). For partial cases where there are a number of scattered natural teeth the pattern

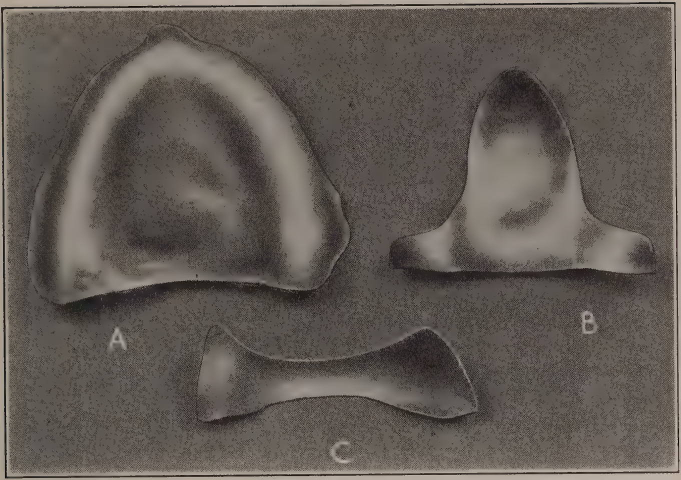

FIG. 427.—*A*, tin-foil pattern of full upper plate made on the die and not on the cast; *B*, pattern of air-chamber and strengthener combined; *C*, pattern for strengthener for the posterior edge of the plate.

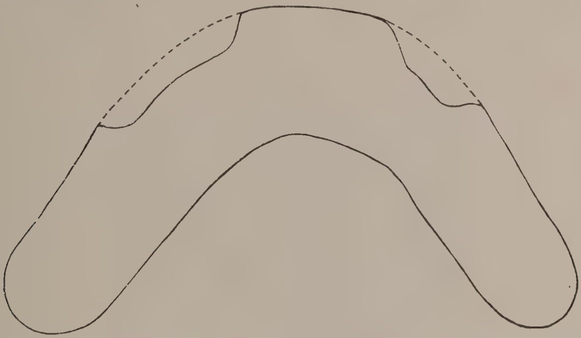

FIG. 428.—Pattern for partial lower plate supporting anterior and posterior teeth. The metal form is cut to the dotted line.

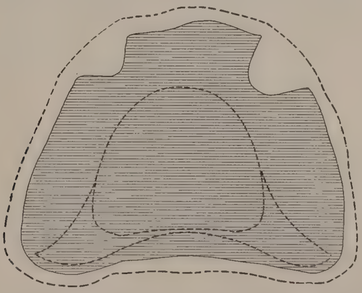

FIG. 429.—Shaded portion shows the pattern for a partial vacuum plate where the canine teeth alone remain. The inner dotted line is the pattern for a vacuum chamber as it is ordinarily made and as it should be when extended to the tuberosity to give rigidity to the wide flat plate.

will be irregular where it goes around these teeth and, in marking it upon the paper, do not run into these indentations, for the reason that when the plate is swaged the slightest deviations are liable to spoil the plate. The small pieces of gold that run between the teeth will not be swaged exactly. The cutting out of the plate to provide for the teeth should not be done until the plate is nearly swaged and only when wrinkles are beginning to form at these points.

FULL UPPER PLATES.

Full upper plates are generally swaged of 18- or 20-carat gold of No. 28 gauge, and when reinforced the strengthening pieces are of the same gage. When an air-chamber is used, a thinner plate is permissible, No. 29 or No. 30 gauge. This is generally a silver alloy, but if great strength is desired the strengthening pieces can be made of clasp metal. The writer does not believe that air-chambers are necessary, and in fact are undesirable, due to the danger of their causing cancer. It is much the better method to simply cover the hard spots with wax, thinning the edges of this wax down so there is no appreciable thickness (Fig. 430). It is the sharpened edge of the relief chamber that caused the trouble in the old-fashioned plate.

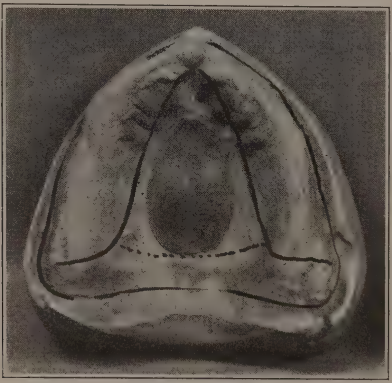

Fig. 430.—Method of preparing cast to form relief over hard spots. Also showing outline of strengthener if used as an air-chamber cap. The portion distal to the dotted line shows the shape of the strengthener if no air-chamber cap is used.

After the pattern has been cut in white paper, it is placed upon the gold and outlined with a sharp instrument, and with a large pair of snips or shears the gold is cut to the shape of the enlarged pattern. The gold is then annealed to a cherry-red, 700° F., and plunged into cold water to soften it. All alloys of gold used for swaged plates are softened by plunging into cold water. This will produce an oxide on the gold which protects it during the further annealing. It is not necessary to plunge the gold into acid after each annealing unless a low-fusing metal is being used for the counter-dies. The writer has for years swaged gold plates without pickling in acid excepting when just ready for solder, and never remembers burning one.

Care should be taken not to have any mercury on the bench, as the slightest drop of mercury will spoil a gold plate.

After annealing, the gold is bent to approximately the shape of the palatal surface with the fingers, and then placed upon the die. It is sometimes recommended that a bone hammer be used to begin shaping the gold. The bone hammer should never be used on the palatal portion of the plate or on any portion of the plate unless its end is covered with rubber, as it will mar the plate and it will be impossible to polish these dents out of the surface. If a bone hammer is used, it should be covered with rubber such as a crutch end or the rubber cup which is sometimes placed over the end of a chair leg. When sure that the counter-die is in the proper position, a light tap with a 7-pound hammer will be sufficient to bring it to place. If the plate is not seated properly it will be necessary to change its position on the die. Do not attempt to swage the plate down with one blow until sure that it is in the proper position, or it may be found that the plate is short at one portion when the swaging is completed.

When sure that the plate is in the proper position, it can be swaged with heavy blows, two or three being sufficient to drive it to place (Fig. 431, *A*). The next step is the use of the second counter-die which will turn the plate over the ridges (Fig. 431, *B*). If it should be noticed that wrinkles are developing, the bone hammer can be used to eradicate them. Care should be exercised not to fold the wrinkles over on themselves as it will be impossible to get a tightly fitting plate with such a fold. If it is impossible to get a wrinkle out of a plate, it will be necessary to split it (Fig. 431, *C*), cutting out sufficient material to allow the gold to almost come together and beveling these edges so that there will be only one thickness of metal. This will require some judgment. Another method of correcting this is to split the fold and allow the pieces of metal to overlap until the swaging is almost completed. The overlapped edges will mark each other, and they are very easily cut off. The slit is then soldered together with a minimum quantity of solder. Before soldering, however, clean the plate in acid solution, 50 per cent sulphuric acid with water. As mentioned above, it is not necessary to do this when annealing, but in annealing, the high degree of heat is not reached as in soldering and there is much less danger of alloying into the plate any particles of zinc or lead that may adhere to the plate.

After the second counter-die is used, follow with the third and then (Fig. 431, *C*) trim the plate exactly to the plate line. The plate should be annealed after each swaging and when the third stage is reached select the fourth counter-die, which is a duplicate of the third, and place in it some cottonoid or sheet fiber cotton. This is moistened, placed upon the plate, which is in place on the die, and the die is struck to drive it into the counter-die. This drives the sides of the counter-die against the die, and the moist cotton between, acting as a hydraulic filler, enables us to obtain a closer fitting plate.

The swaging should be done upon the anvil. A convenient anvil may be made of a short section of a locomotive axle or a similar heavy piece of metal and set in a box of sand or a box filled with newspapers. If this is mounted on a car spring, its use imparts no shock to the building, and there is sufficient mass of metal in the anvil to resist the blow from a 7-pound sledge-hammer.

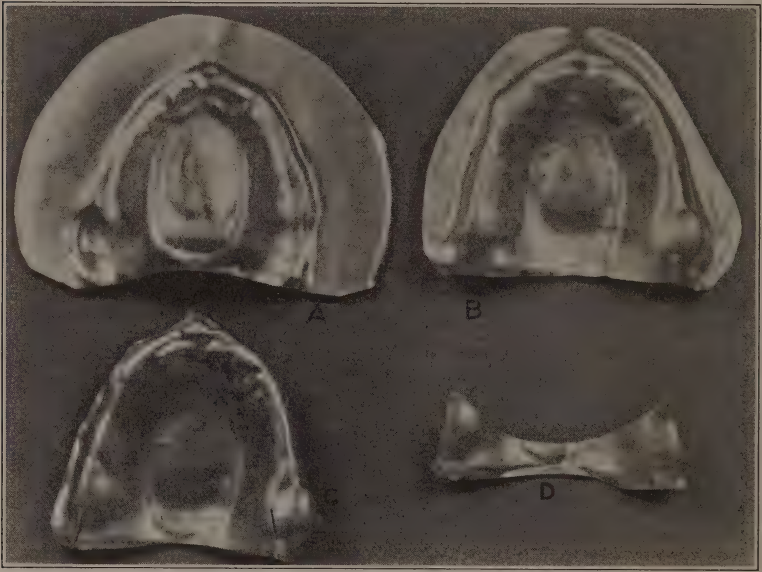

Fig. 431.—*A*, gold plate swaged with first counter-die; *B*, gold plate swaged with the second counter-die turning the gold over the ridge; *C*, gold plate swaged with the third counter-die, showing it split at the heels of the plate where the wrinkles form; *D*, strengener swaged to be placed upon the palatal side where it adds thickness to the plate and assists the suction, especially in soft mouths; also allows the distal edge to be more rounding, which prevents the cutting of the tissues.

When the die is removed from the counter-die, the plate sometimes sticks in the counter-die. This is due to the fact that the lead, coming over the edge of the plate, holds it. This will be obviated by the use of cottonoid, as mentioned above, or a sharp penknife can be used to cut off the little pieces of lead which force themselves over the edge of the plate. The plate should never be pried out of the counter-die, as prying is liable to bend it. If it persists in sticking, take the counter-die in one hand and strike its flat surface upon the anvil and the plate will generally be dislodged.

If strengthening pieces are being swaged, it is best to swage them first while the counter-die is new (Fig. 431, *D*). The same thing is true of an air-chamber. If an air-chamber is used it is permissible to drive the plate down around the edges of the air-chamber pattern to make it fit more snugly, using for this purpose a chisel-like tool made of bone or copper and called a "chaser." This should not be done on the chamber cap as the cap will be marred, and as the chamber cap is made of thinner metal than the plate, it is easier to swage. The air-chamber should be cut from the plate and filed very accurately to the outline. Care should be taken to file this edge parallel with the bevel of the air-chamber cap, so that when the two are soldered together there will be one continuous line from the plate to the bottom of the air-chamber. The chamber space can be cut out by means of a plate punch or holes can be punched near the edge and the metal sawed out with a bracket saw.

After the metal is cut out the air-chamber cap is trimmed to shape and the edges beveled so that they present no sharp edges to the tongue. The plate is placed on the die, the air-chamber cap is placed over it in the proper position and a counter-die is carefully placed in position so as not to disturb it and a light blow of the hammer struck to conform them to each other. Do not use heavy blows, as the plate will spread where it is cut out.

The pieces are now ready for pickling and soldering. If the plate is made of two laminæ of metal, one a thin one of pure gold and one a thicker one of 20-carat gold, each lamina is swaged separately, allowing the thin one to extend slightly over the edge of the plate outline. The thick one is trimmed exactly to the plate outline. The two are swaged together and the thin piece which extends makes a good shelf upon which to rest the solder when soldering. It is practically impossible to solder otherwise.

The two-laminæ denture is more often used in the lower than it is in the upper jaw, as the lower ridges are sometimes thinner and it is almost impossible to swage accurately to them unless two laminæ are used. This makes a very heavy plate, however, and patients often object to the weight of the denture.

It is best to try the plate in after swaging it on the zinc die. If it fits, no more swaging is necessary. If it does not fit, it is swaged on the Babbitt's metal die. It sometimes happens that it does not fit even after this and in that event it will be necessary to make a new model with its dies and counter-dies. Before this is done, however, it is best to determine just what is wrong with the plate. Sometime nothing more is wrong than that it is not sufficiently post-dammed; that is, there is not sufficient pressure at the posterior edge. This can be determined by melting a little carding wax or modeling compound along the posterior edge of the plate and placing the plate in the mouth. If adhesion is obtained the die should be ground with a stone over the area determined by the post-damming and the plate reswaged. If this is not the trouble, it will be necessary to place modeling compound in other places. First determine whether the plate rocks on the palate. If so, a new impression will have to be taken and this is best done by using the gold plate as a tray. If it does not rock, see upon which side it drops. Pressure on one ridge will cause it to drop on the other, which means that there is not sufficient pressure on the buccal and labial surfaces of the plate. This can also be corrected with modeling compound or wax, but in this instance, as in the case where it rocks on the palate, it will be necessary to pour a new cast. This can be done immediately on the inside of the plate, without taking a new impression.

FULL LOWER PLATES.

The swaging of a full lower plate is the same as the swaging of a full upper plate, but it will generally be necessary to split it in the median line, on the lingual side, to the top of the ridge, to make the gold conform with the die, unless it is a case with a very flat ridge. Full lower plates are generally made of two laminæ of metal.

PARTIAL PLATES.

Partial plates present many difficulties in swaging and it is best to make a study of the model and so design the counter-dies that the gold will be gradually worked into the interspaces between the teeth. If there is a tendency of the gold to wrinkle, it should be split before the wrinkle goes too far and forms a fold. Partial lower plates are generally made of two laminæ of metal, one of a higher carat and a thinner gauge which goes next to the tissue. The thinner gauge, strange to say, is the most difficult to swage, as it is much more liable to wrinkle and tear than the thicker gauges of metal. If it should tear slightly at the edge of the plate, that need not cause any concern, for when we solder it to the thicker lamina, the solder will fill up the little crack. If the crack is too large, it becomes necessary to solder a piece of the same gauge gold over it to prevent the crack from going any farther. If a big fold occurs, the best thing to do is to split it, cut off the folded metal, bevel the edges of the split and flow solder over the split.

When the first piece is swaged the second or thicker piece is swaged. Sometimes a strengthening piece is swaged to fit between the two thicknesses of metal, especially in a partial lower where the anterior teeth are present or in the case of a partial upper of the horseshoe variety (Fig. 432). These strengthening pieces are generally swaged of clasp metal of about No. 28 gauge in thickness or even as low as No. 30 gauge. They are placed in their proper positions and the three laminæ are swaged together. Before doing this it is sometimes best to attach the strengthening piece with solder to the thinner piece of metal (Fig. 433, *A* and *B*).

Where the teeth are scattered there is sometimes great difficulty in swaging, and more so when an attempt is made to run the gold up on the lingual surfaces of the teeth. If there are only a few teeth, it

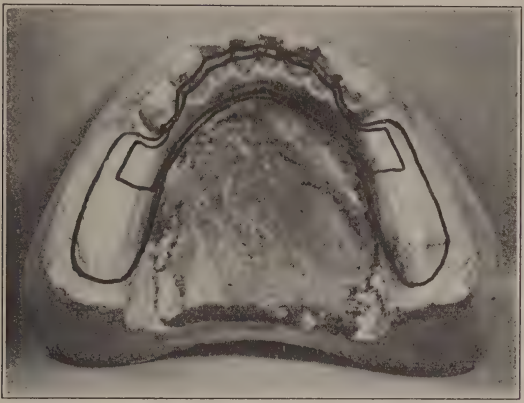

FIG. 432.—Outline for an old-fashioned partial lower swaged plate with strengthener. This type is rapidly being superseded by the lingual bar and the double-bar dentures.

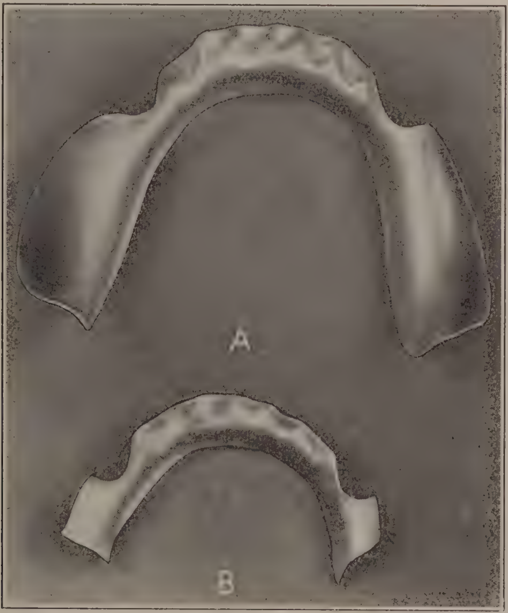

FIG. 433.—*A*, the first lamina swaged, No. 28 or No. 29-gage gold of 22-carat or pure gold. (This lamina should be slightly larger than the third one of No. 28 gauge 18 carat to allow a shelf to rest the solder on when soldering); *B*, the strengthening piece of clasp metal No. 29 or No. 30 gauge.

is best to terminate the plate at the gingival margin and then swage small pieces to fit around the teeth. These pieces are then soldered to the plate, and, finally, the whole plate is reswaged.

SOLDERING.

The soldering of a denture calls into play a good deal of skill. The parts should be pickled in dilute sulphuric acid (50 per cent) after soldering, and the plate washed to remove all traces of the acid. Next, the parts should be fluxed with a saturated solution of borax and a saturated solution of boracic acid, equal parts. It is best to dry them with a gentle heat before placing them together, as the flux, if it is not dry, will bubble and cause the laminæ of the metal to be forced apart. The metal pieces are brought together and held by means of spring clamps.

These springs can be made of stove-pipe wire, twisting them around the beak of round-nosed pliers with the fingers (Fig. 434). They must be so made that they will close when the heat is applied to them. This is done by making the ends cross one another at one point; otherwise, they will open up in the flame and be useless.

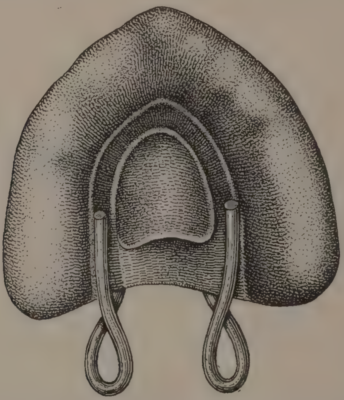

Fig. 434.—Soldering springs or clamps. The ends should always cross to prevent opening when the flame of the blow-pipe is applied.

When we have a sufficient number of springs placed upon the plate to hold the parts together we cut the solder in small pieces, which, having been thoroughly fluxed, are laid around the edges of the plate on the thin piece of gold. Placing the plate on the soldering block, it is gently heated and the solder is drawn through from one side to the other.

In soldering an air-chamber in an upper plate, it is best to place the solder at the back edge of the chamber and draw it through to the front. If the plate is clean and there is good contact and good flux, there will be no difficulty in soldering. These are the requisites for soldering.

The proper application of the heat should also be mentioned. It is desirable to start with a large brush flame, get the entire plate heated and then narrow the flame down slightly where we want the solder to flow to any one point. Never wave the blowpipe over the work. It should be moved gently to prevent any one point of the plate becoming overheated.

After soldering, the plate is pickled to remove any borax or antiflux. Any excess quantity of solder is removed by filing or grinding and any surplus of gold trimmed away, especially in the two-laminæ plates where the thin gold is trimmed down to the edge of the thicker. The plate is then reswaged to remove any distortion that might have occurred in the soldering.

It is now ready for rimming or attaching lugs to hold the vulcanite. The writer has discarded rimming on the buccal and labial surfaces, as it is too difficult to determine just where the rim should go and he doubts the value of its retentive qualities. Also, if it is necessary to trim the buccal edge after the denture is settled, since the rim is very narrow, there is danger of cutting through it, leaving a rough and unfinished edge. With casts made from models obtained by the current method of modeling compound impression taking, the plate is not swaged up to the very edge but terminated about $\frac{1}{8}$ inch from the plate margins. This is filled in with the rubber, which when vulcanized gives a very accurate fit at the peripheral margin and also better adhesion. The writer has made many full gold dentures that have held the vulcanite for years with no other attachments than the spurring done with an engraver's tool. In partial plates attachments will have to be made to hold the rubber. These are generally made of little loops of metal soldered to the plate.

Rimming on the palatal side and attachments are described in a subsequent portion of the text under the Pryor method.

A TECHNIC FOR MAKING ACCURATE DIES FOR THE SWAGING OF METAL DENTURE BASES.[1]

"The metal base denture has not enjoyed the universal approval of the dental profession in the last decade. There have been many who have asserted that metal base dentures cannot be depended on to exhibit as good retention as vulcanite base dentures. This opinion was held by the writer up to about 1920, when he had the privilege of seeing the method of making dies described in this article demonstrated by Dr. C. J. R. Engstrom, of Los Angeles. Since that time the writer has utilized this technic in constructing metal base dentures with the most gratifying results.

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[1] Tench, R. W.: Jour. Am. Dent. Lab. Assn., August, 1926.

Battersea Public Library.

"In the past unfavorable results encountered using swaged bases were due, no doubt, to the impossibility of accurately reproducing the contour of undercuts and to the tendency of the metals utilized for dies to deform on cooling. When undercuts were present the metal base would usually be warped by forcing it off the die, and the die itself usually did not accurately reproduce the contour of the cast which it was supposed to duplicate.

"The two outstanding features of the technic to be described are the sectional method of making a mold in which to cast the die and the use of a low-fusing die metal.

"The sectional mold permits the reproduction of all undercuts present in the model, as well as the production of any number of dies desired in any chosen material. The utilization of fusible metal for a die, at least for mouths presenting undercut contour, permits of the die being melted out of the finished base and eliminates the possibility of warping the base in slipping it off the die.

"The sectional mold is made of equal parts of Standard investment and Kerr's Snow White plaster or of 2 parts of river sand and 1 part of plaster.

"The die may be cast of any alloy, which neither expands nor contracts, fusing below the boiling point of water. The writer uses Ney's Dialoy or a combination of Ney's Dialoy and S. S. White's Melotte's. One ingot of Melotte's to 6 of Dialoy will yield a somewhat harder die when this is wanted.

"It is assumed that the cast of the mouth has been prepared by building on wax for necessary relief and coated with sandarac.

"The technic of making the sectional mold can be best understood by studying the illustrations that follow.

"Fig. 435 shows pieces of compound covering the right and left bucco-labial sections of a cast. These are shaped to interlock in front and to cover the crest of the ridge.

"Fig. 436 shows the palatal section of the three-piece mold, cast in porous material. The center of this section is scooped out so that the palate of the cast is covered by a layer about $\frac{1}{8}$ inch in thickness. The shoulder in the scooped out part of this section supports the cardboard cover and brass tube shown at the right. The cardboard and tube are best attached with plaster of Paris to the palate section of the mold after all sections are complete and they have been removed from the cast.

"When the palate section is hard one of the compound side sections is carefully removed. The exposed surfaces of the palate section of the mold are smoothed with a sharp knife and coated with sandarac, then polished with cotton and vaseline or treated with some other suitable separating medium, following which the second section of the mold is poured.

"Fig. 437 shows palate and one side section of mold poured, ready for application of the separating medium and pouring of the third section of the mold.

"Fig. 438 shows the three sections of the mold removed from the cast reassembled and held together by a stout rubber band.

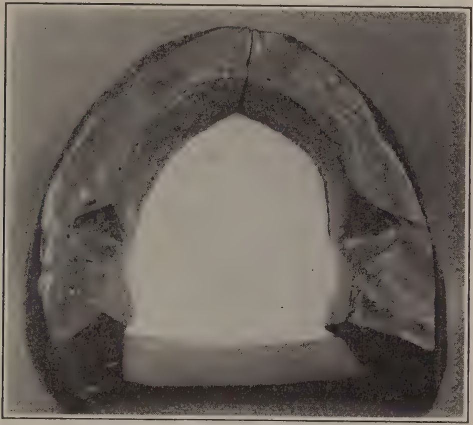

FIG. 435.[1]

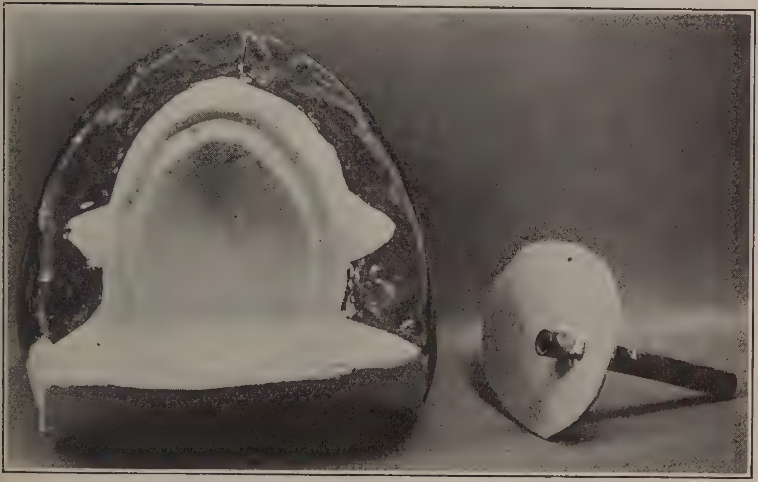

FIG. 436.

"Fig. 439 shows detail of the chamber formed in the palate section of the three-piece mold. When casting metal dies a rubber hose is attached to the brass tube and connected to the saliva ejector. The vacuum thus formed in the hollow chamber of this piece of the mold allows escape of the gas that would be trapped in the palate portion

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[1] Figs. 435 to 444 reprinted from Tench's article in the *Dental Forum*, through courtesy of Miller-Roth, Inc., Pittsburgh, Pa.

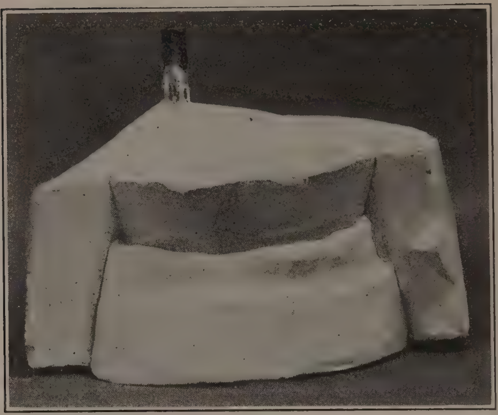

FIG. 437.

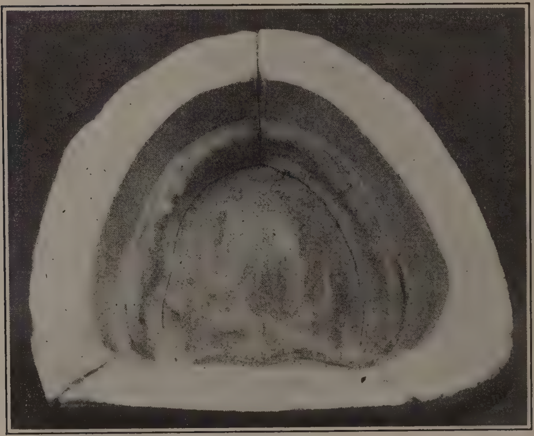

FIG. 438.

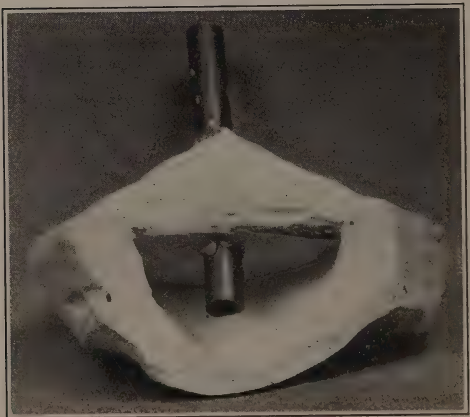

FIG. 439.

of the mold when the fusible metal is poured. The use of the vacuum as described is necessary to avoid a rough or pitted surface on the palate of the fusible metal die.

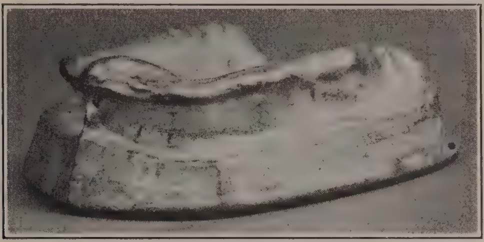

Fig. 440.

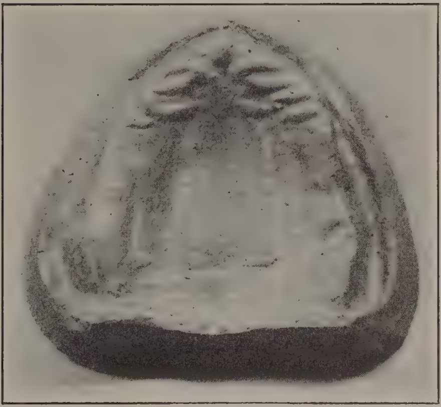

Fig. 441.

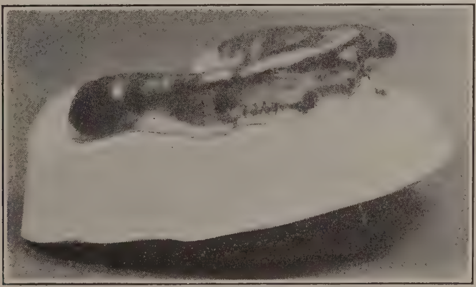

Fig. 442.

"Fig. 440 shows a Spence metal die which was cast from a three-piece mold. When casting Spence metal the surfaces of the mold are coated with vaseline. It is not necessary to employ any vacuum in casting either Spence metal or stone in these molds.

"Fig. 441 shows a Dialoy die of an irregular and undercut cast.

"Fig. 442 shows a metal base for the case swaged over a fusible metal die and returned to the model. After prominent interferences had been removed that prevented the seating of the base on the cast without warping, the base rested dead against the cast and exhibited less than $\frac{2}{1000}$ inch error in peripheral contact at any point. A duplicate of this base in Pryor metal has been worn eight months and the patient has always experienced difficulty in dislodging it for cleansing. Previous to the insertion of the denture mentioned this patient had had made by various dentists two cast-base dentures, one swaged base, one gold-coated vulcanite and two vulcanite dentures, none of which could be retained without adhesive powder.

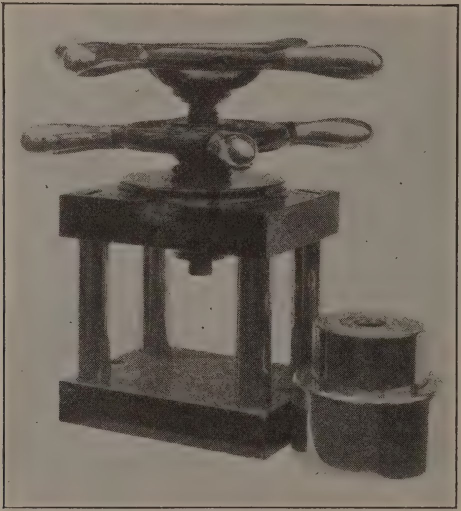

Fig. 443.

"Fig. 443 shows the press designed by Dr. W. J. Pryor, of Cleveland, which the writer uses in swaging metal bases.

"Fig. 444 shows, at left, the cup of the Pryor swager with a lower Spence die swaged into compound in the cup of the swager. At the right is the plunger of the swager with Ash's soft rubber block resting on top of the plunger.

"In conclusion, let me say that it is possible for a careful technician to make comfortable, accurately fitting, swaged metal base dentures for at least 90 per cent of edentulous patients, with all the advantages of comfort and oral health heretofore ascribed to the swaged metal base by the leading technicians of the past. Dentures made with swaged bases are certainly to be preferred to those of cast metal or vulcanite, both from the viewpoint of oral health, comfort and conservation of ridge tissue."

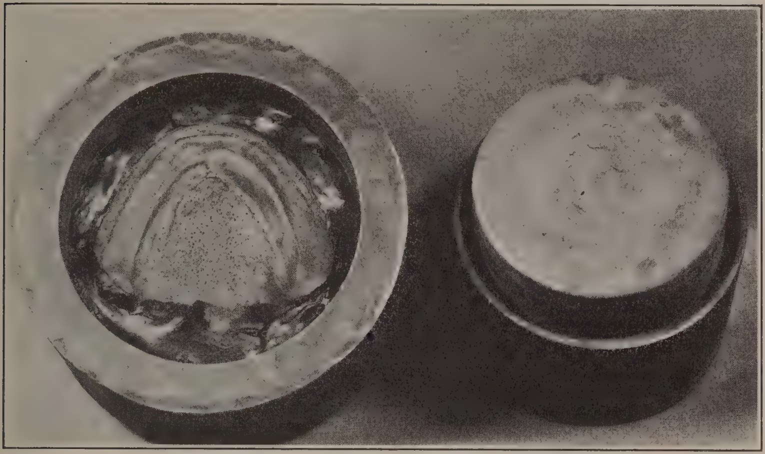

Fig. 444.

PRYOR METHOD OF SWAGING OR MACHINE SWAGING.[1]

"That the soft tissues within the area covered by an artificial denture remain more nearly normal if a metal base-plate is worn, is a fact which has been noted by many observers. This is due to a property possessed by nearly all of the metals, namely, an inhibitory action on bacterial growth, and also because the dense surface which a metal base-plate presents permits it to be more easily and thoroughly cleansed. The unfavorable action on bacterial growth ranges all the way from a definite germicidal action in the case of mercury, to a very slight inhibitory action with the noble metals. Various metals have been used for denture base-plates. Among them are platinum, palladium and gold and their alloys; silver, aluminum and some of the baser metals to a small extent. Gold alloys both swaged and cast have in the past been accepted as being most satisfactory. However, some alloys which have been little used, while having all the good qualities possessed by the gold base, exhibit some marked advantages over gold.

"In the writer's hands an alloy of palladium, $\frac{1}{3}$, and silver, $\frac{2}{3}$, has shown exceptional merits. It is very strong, permitting its use in thinner gage than gold. Its weight is only slightly more than one-half that of gold, making a much lighter denture. Its silver content has marked inhibitory action on bacterial growth, as shown in laboratory tests. It polishes to a beautiful white luster and retains its color in the mouth, due to the palladium content which prevents the discoloration by sulphur compounds, to which silver alone is subject (Fig. 445).

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[1] Pryor, W. J.: Jour. Am. Dent. Lab. Assn., August, 1926.

"The technic for its construction is as follows: A modeling compound impression is made from the original cast, and a second cast of artificial stone is poured. If the original cast has marked undercuts, cores, also of modeling compound, are used to obtain an accurate impression. The swaging is done on this second cast, which is coated with a solution of flexible collodion to prevent chafing or marring of the surface. The old type Lyon swager, improved to provide more room and greater strength, is employed. The swager is a double screw (one inside the other) press (Figs. 443 and 444), one screw forcing the piston into the ring and the second screw passing through a hole in the piston directly into the rubber, an Ash soft-rubber block being used. The stone cast is pressed into soft modeling compound well down in the ring (Fig. 444). The case is put into the swager while the compound is still soft, and fair pressure is applied until the water and air bubble out between the piston and ring. The pressure is not relieved until the compound has cooled. (This is an important step if we are to avoid breaking the cast.) The compound is in this manner condensed around the cast, preventing any breakage.

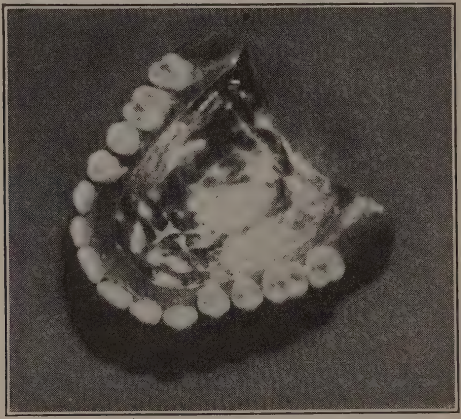

Fig. 445.—Finished plate with vulcanite attachment for holding teeth.[1]

"A flat piece of No. 29-gauge metal, cut to pattern and annealed, is placed over the cast and held in proper position with a small amount of modeling compound at the edge. Quenching in cold water is not recommended in annealing this metal. Cooling on the bench, or, after a moment's wait, in warm water, produces better results. The case is placed in the swager and screw pressure applied. If the metal shows a tendency to buckle over the undercuts, cut it and let it lap over, and continue swaging with frequent annealing. The metal is soon shaped and the overlaps are soldered with low-fusing platinum solder, the overlapped edge of metal having been previously beveled (Fig. 446, *A*). A reinforcement of 28-gauge metal is swaged over this base and cut to proper size and shape to make the stopping point (or line) of the vulcanite at the lingual side of the teeth (Fig. 446, *B*). The edge of this doubler is raised at its periphery to engage the vulcanite, by swaging three thicknesses of Ash's No. 7 soft metal over the base on the cast, and cutting the lingual region out so that the soft metal extends 1 to 2 mm. under the edge of the reinforcement at its last swaging. The center of the reinforcement is cut out, using an edge cutting finishing bur (Fig. 446, *C*), and it is soldered to place on the No. 29-gauge base. This center piece is not cut out entirely, however, until after the reinforcement is tacked in position with solder. It is left attached at two or three points to facilitate holding the piece in place. If the technic is correctly followed no solder should show in the finished case. This is made possible by burnishing the edge of the reinforcement down onto the base before the soldering is continued from the underside. This leaves but one thickness of 29-gauge metal over practically all of the palate portion of the denture. A number of lugs are now soldered on the base for vulcanite attachment (Figs. 447 and 448).

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[1] Figs. 445 to 449 reprinted from Pryor's article in the *Dental Forum*, through courtesy of Miller-Roth, Inc., Pittsburgh, Pa.

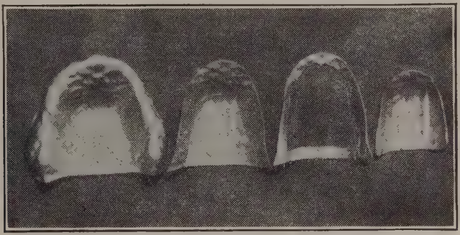

Fig. 446.—*A*, base of 20-gage metal, showing rugæ; *B*, reinforcement also bringing out the natural rugæ; *C*, the part of the reinforcement which is used; *D*, the part of the reinforcement which is discarded.

"The original cast is, as the last step in the technic, placed in the swager and the final swaging done on it to correct any possible discrepancies. The free edge of the reinforcement is held in place during this last swaging by flowing sticky wax between the base and the reinforcement, which prevents it from being swaged flat down onto the base. This reinforcement has a much desired characteristic of being readily adjusted up or down to meet the lingual wax at the proper contour.

"In this technic no metal die or counter-die is used, and no hammering is done at any time. The rugæ of the particular mouth being fitted, are brought out distinctly in the metal base, and the denture when completed is very thin and light in weight. It is cool in the mouth, natural feeling to the tongue and the tissues covered by it are kept in good tone.

"We also often use a slightly more complicated technic in constructing the lingual reinforcement, which carries the metal right up to the porcelain teeth (Fig. 449). This produces a more beautiful case and insures having the proper contour to the rugæ area. This area, $\frac{1}{2}$ to $\frac{3}{4}$ inch backward from the anterior teeth, is where the tongue plays on and near the hard palate in producing many sounds. (Try this out on yourself by saying the letter "S," the word "church," etc.)

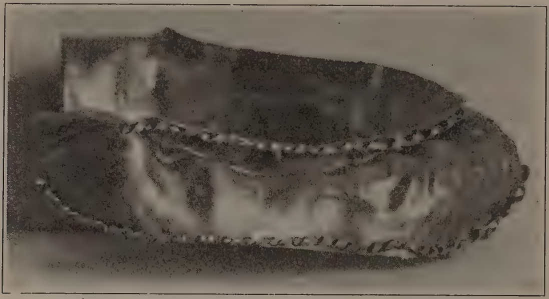

Fig. 447.—Swaged plate showing lingual reinforcing plate and attachments for vulcanite.

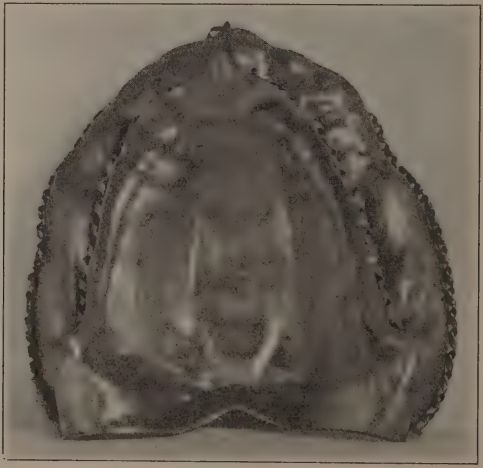

Fig. 448.—Swaged plate, lingual view.

"Study the shape of this area by taking compound impressions of mouths with the natural teeth in place, and obtaining plaster casts. It is a very important area, and is seldom reproduced properly. In this technic we first finish the base of No. 29-gauge metal, obtain central occlusion, set up the teeth and carve the lingual contour.

"Next take a plaster impression of the entire lingual aspect, including the teeth up to the occlusal surfaces; remove this plaster impression and varnish (sandarac) it, chill the wax and remove the teeth from the base in two or three wax sections and lay them aside in cold water for future replacing on the base.

"The plaster impression of the lingual surface is placed on the base, and a mix of stone is packed in from the sides into the space formerly occupied by the wax and the teeth. The base is now carried to the "master cast," which has been previously placed in the swaging ring, and more stone is packed in, to carry it out to the sides of the ring for strength. This stone is left to harden overnight and the plaster lingual impression is removed, revealing a reproduction of the teeth and lingual carving in stone. The lingual metal, No. 28 gauge, is now swaged and burnished to this surface. Three strips of metal may be soldered together for this lingual piece, if we wish to economize with our metal.

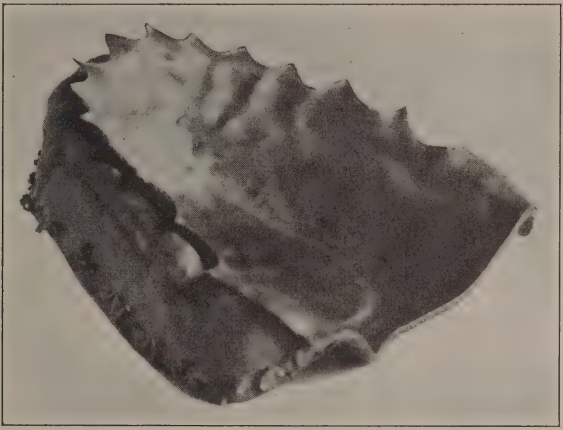

FIG. 449.—A swaged plate showing lingual reinforcement running up to the edge of the teeth.

"The upper surface of this stone reproduction of the lingual portion is now slightly heated with a blow-pipe so that it can be removed. The lingual metal is soldered to place on the base. We again use 1000 low-fusing platinum solder, and use a slate pencil with a weight leaning against it to hold the lingual piece in place on the base until it is tacked with solder. The slate pencil being a non-conductor does not carry away the heat from the work, which must be very hot in using this solder.

"In this technic the solder is applied in view on the lingual surface, as its color is excellent and does not discolor in the mouth. After the lingual piece is soldered to place the final swaging is done, first packing in stone between the lingual piece and the base to hold the lingual piece up in place under the swaging pressure. This stone, of course, must be allowed to harden at least twelve hours before the final swage."

CHAPTER XIII.

CASTING METHODS FOR METAL BASE DENTURES.

BY GEORGE H. WILSON, D.D.S.

REVISED BY

I. LESTER FURNAS, D.D.S.

THERE are four physical principles usable in dental casting methods, namely, gravitation, centrifugence, vacuum and pressure.

There are three metals with various alloying metals used for dental castings. The metals suitable for dental castings are tin, aluminum and gold; the alloying metals are silver, copper, bismuth, nickel, magnesium, platinum and palladium; also tin and gold are sometimes used for alloying.

The necessary material and equipment for casting consist of suitable investment compounds, waxes, fluxes, instruments for forming the wax, and machines for heating and casting. The machine and equipment suitable for each of the three metals for casting will be considered in connection with the technic for the same.

Necessarily each method has its technic and each metal its properties that need to be considered in detail.

Gravitation Method.—Gravitation—weight—does not imply that the heavier metals are suitable for this method for they are not, but a low fusing-point of the metal used is the essential factor for this method of casting. Tin (and its alloys) is the one metal suitable for this principle of casting.

History gives credit to Dr. Edward Hudson of Philadelphia (1820) as being the first to attempt casting denture bases of tin; however, the method was not successful until Dr. A. A. Blandy of Baltimore presented his method to the profession in 1855. All later methods devised have been developed upon the Blandy method. His alloy was silver, bismuth and antimony, but the tin alloys soon followed and were accepted. Blandy called the method "Cheoplasty" or pouring method. The alloys of tin that have been used by the profession are: Kingsley's alloy, tin 16 parts, and bismuth 1 part; Reese's alloy, tin 20 parts, gold 1 part and silver 2 parts; Bean's alloy, tin 95 parts and silver 5 parts. Watt's and Weston's alloys are proprietary preparations, but are the ones purchasable and are probably similar to the alloys of Bean and Kingsley.

The tin base denture is better adapted to full lower dentures than for any other; however, Reese's alloy was advocated for partials and upper as well as for lower dentures.

Technic.—The necessary equipment for this work is a two part flask (Watt's) (Fig. 450) and a small ladle or large spoon. Any good high heat investment compound will serve for this work. In addition to the wax spatulas and heating appliances found in any dental laboratory, a wax sprue former (Fig. 451) and a special heating apparatus as shown in Fig. 452, are very valuable additions.

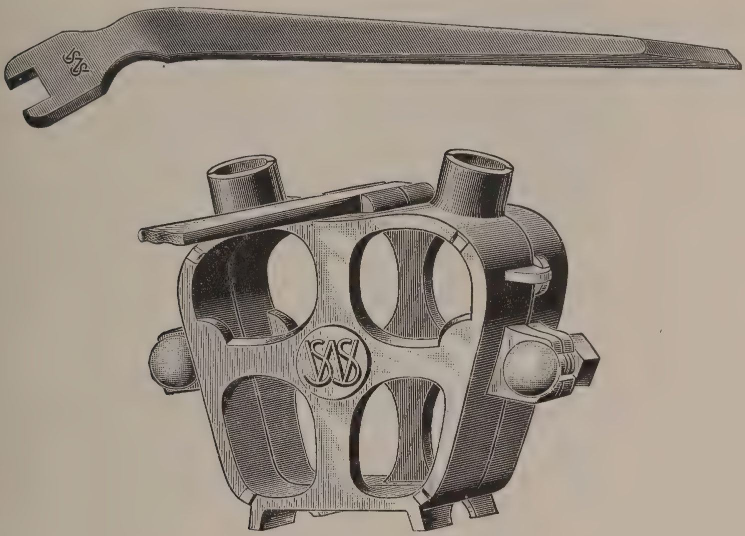

Fig. 450—Watt's casting flask.

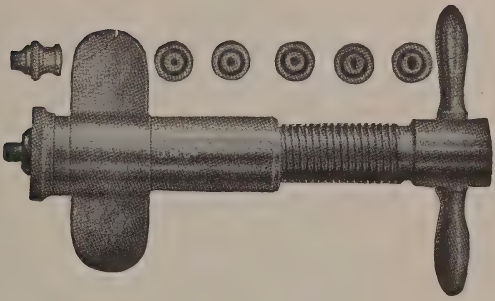

Fig. 451—Wax sprue former.

The cast made by filling the impression must be of investment compound. The pattern base-plate may be formed of any good casting wax. The wax additions to the base-plate, as the thickened periphery and retainer cleats, are best formed of yellow wax. These additions may be formed of a strip of wax, but better with a wax sprue former. The peripheral border may be outlined with wax formed by the large oval wax nozzle, or the nozzle may be left off and a still larger round wax may be formed. This will give sufficient material to form the border as desired by the aid of a hot wax spatula and small carving knives, as 1 and 2 of the Evans' set. The retaining cleats are best formed with wax formed with one of the small nozzles. The wax model must be thoroughly sealed to the cast. This is done with the hot wax spatula.

Fig. 453 shows the cast and wax model base-plate flasked in the first half of the flask. It also shows the pouring sprue and the vent sprue formed of wax. These wax pouring and vent sprues are unnecessary as the desired openings can be carved from the investment when the flask is opened for removing the wax model.

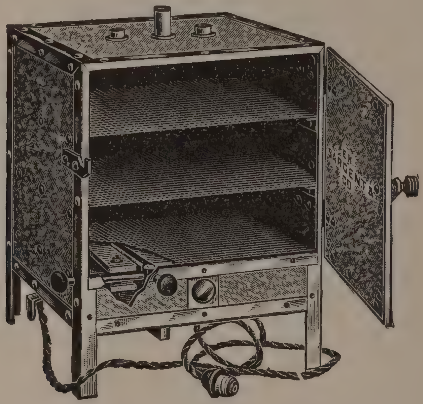

FIG. 452.—Sargent electric warming oven.

The investment, having been trimmed smoothly to the periphery of the wax model, is treated with any good separating fluid. The writer prefers, as a separator, for all kinds of flasking a lather of soap, as no line of demarcation is needed and there is less body to the soap than to the varnishes. A lather rubbed up with a wet brush on a cake of Ivory soap is best. (Should one fail to get good results with the soap he should thereafter apply the lather more generously.) The upper section of the flask is firmly bolted in place and the wax model moistened so as to aid the investment compound flowing perfectly to its surface. The investment compound is smoothly mixed, *not* too thick, a portion poured into the flask and thoroughly jarred into position. When the flask is full it is permitted to stand until thoroughly hard (one-half hour). The bolts are removed and the flask placed in a warm place to soften, but not to melt the wax model. The Sargent Electric Oven set for 220° F. (Fig. 452) is most excellent for this purpose. About ten minutes will be required for this warming. The Interval Timer (Fig. 454) is useful for timing. The flask is then opened and the wax lifted out bodily. The small portions used for forming the retaining cleats may be left; no attention need be given to these as they will be dissipated in the drying out process.

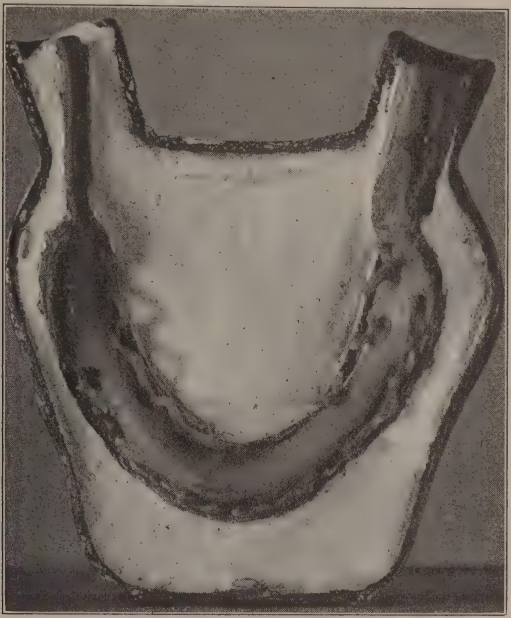

FIG. 453.—Wax base-plate flasked.

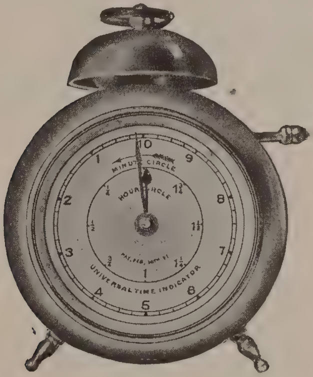

FIG. 454.—Interval timer.

It is essential that the investment compound shall be so dried of moisture that no steam may be formed in pouring molten metal of 400° to 500° F. into the mold. However, should there be a slight bubbling of the poured metal, indicating that steam is being formed, the flask should be grasped by the handle and carefully jarred until the metal solidifies. The drying out can be done upon a piece of sheet iron upon the gas stove, or upon the R. & R. Radiant heater (Fig. 455). The case should be well dried in one-half to three-quarters of an hour. The two sections are bolted securely together, the handle inserted, and the metal thoroughly melted, that is, from 50° to 100° F. above its fusing-point. The molten metal is then poured into the feed gate until it appears at the vent gate, and as before stated if any bubbling appears the flask should be gently rapped upon the bench until the metal congeals. The flask is permitted to stand until it can be handled with the bare hands when it may be placed in cold water and left until the investment is soaked and softened. The flask is opened and the casting scrubbed clean of investment. The gate metal and any excrescences not desired are cut away with nippers, saw or file. The peripheral portion is finished with file and sand-paper and tried in the mouth. If the casting is satisfactory it is ready for its superstructure of vulcanite attachment.

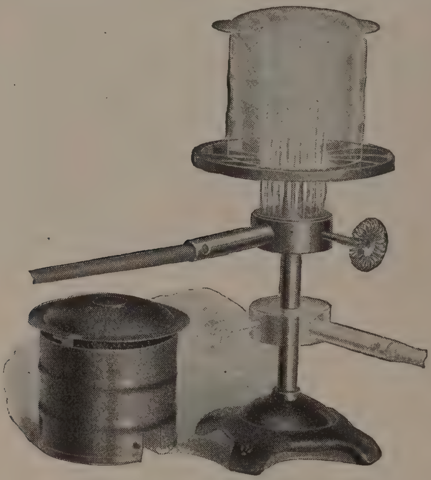

FIG. 455.—Ransom and Randolph radiant heater.

Centrifugence, Vacuum and Pressure.—These methods are all suitable for the two remaining metals, aluminum and gold; however, each method has its advantages and disadvantages.

Centrifugence is the force which is developed by matter revolving about a rotation center which is exerted toward throwing the matter off at a tangent from the rotation path. This power is proportional to the velocity and weight of matter. The principle has the advantage of great simplicity, as an effectual machine may be formed by a basket swung at arm's length; or gear wheels may be utilized to shorten the radius and increase the velocity. This principle is dangerous because of the possibility of accidentally throwing the molten metal out of the machine.

A vacuum is produced by the exhaustion of air from an enclosed space, and the power is the weight of the column of external air compared with the degree of exhaustion of the confined air. Therefore the vacuum machine is a modified form of the pressure machine. Its advantages are that the method permits the application of heat while the force is acting, if desired, and it admits observation of the disappearing metal. Its disadvantages are that its power is limited (but enough for practical use), and its force is forward, very little lateral or backward; however, this disadvantage can be practically overcome by manipulation. This disadvantage and the method of overcoming it is nicely illustrated in the instructions given by the Ransom & Randolph Co. for the Laing method with the Elgin Casting Machine (Figs. 456 and 457).

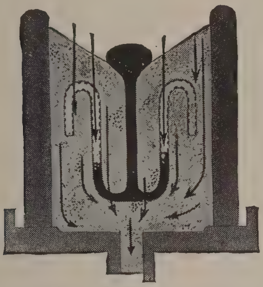

Fig. 456.—The old way. Pressure equalized in the mold, preventing rise of molten metal. Top of investment sealed—pressure concentrated. (Ransom & Randolph Co.)

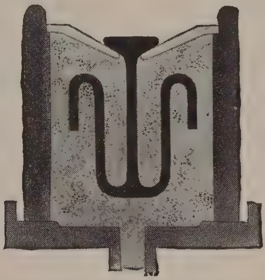

Fig. 457.—The new Laing-Elgin method. Downward pressure centralized by porcelain crucible. Metal follows channel in mold in all directions. Top of investment sealed — pressure concentrated. (Ransom & Randolph Co.)

Pressure principle. This has the greatest range of application and power. The pressure may be created by compressed air or other gases, steam or explosions. The advantages of this principle are that the power is unlimited and may be continuous if desired, also it acts to force the molten metal in every direction and holds it under pressure as long as desired. The disadvantages are that the heat must be removed, the compression tends to cool the metal and the molten metal is out of sight. Fig. 458 shows the perfection with which molten metal is forced in every direction under direct pressure. (Cast by a Burns' Machine, 13 B. & S. gauge 1 inch downward and 9½ inches in a spiral upward. Ney-Oro "B", melted with gas and air, 15 pounds pressure.)

Investment compounds. The investment compound in which aluminum or gold is to be cast should be of high grade, that is, one that will stand a high temperature, does not shrink, but rather expands, is as good a conductor of heat as possible, does not contaminate the molten metals, and has sufficient resistance to force to withstand the necessary pressure used in casting. Also it must be sufficiently porous to permit the escape of gases. The materials that have been used and some of which are in all investment compounds are: Plaster of Paris (calcium sulphate), lime (calcium carbonate), marble dust and chalk (both calcium carbonate), clay (aluminum oxide), fire clay (silicated clay), asbestos (silicate, magnesium and calcium oxides), Portland cement (silicated lime and clay), pumice (volcanic scoria), sand (silica), graphite (carbon), and iron oxide. The last three are of the more refractory materials and these are in the order named.

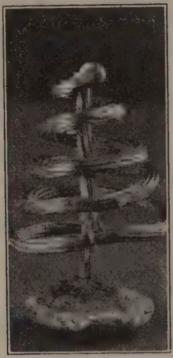

Fig. 458.—Casting made by the direct pressure principle.

Plaster of Paris is a necessary ingredient of all investment compounds because it is the only one that has suitable bond properties. Portland cement is very slow setting. However, there should be no more of the bond material than is necessary for the desired strength. Plaster of Paris shrinks badly under heat and fuses at a red heat. Any of the compounds of aluminum oxide or of calcium oxide shrink under heat. Quartz (silica) has the valuable property of expanding under heat and is the best conductor of heat of any of the materials entering into high heat investment compounds. Silica may be used in the form of crushed quartz (best) or as clean fresh water silica sand. Sea sand is unsuitable for investment compounds unless it is freed of all fluxional sea salts. Fire clay and similar substances must be first thoroughly burned and crushed. Therefore, most of the investment compounds upon the market are formed of the bond (plaster) and silica. A portion of the silica is used coarse (sand) as the framework of the compound, and a portion of the silica is used as a fine powder (flour) to act as a filler and to give a smooth surface to the investment. The writer does not comprehend the desirability for the use of graphite and iron oxide in investment compounds; however, they are used and especially graphite is used in some of the most popular compounds upon the market.

The undergraduate student, for whom this discussion of materials is presented, is not supposed to prepare his own investment compounds, but to use the compounds recommended in the technic he is studying. However, he should know somewhat of the properties of the probable ingredients of the compound he is using, so that he may use the compound intelligently and be able to trace faults to their proper source, whether the defective result is due to the material used, technic procedure, or his personal equation. It is only from a just comprehension of all three of these sources of imperfect results that the student can best qualify himself.[1]

Waxes.—Wax is a general term applied to solid fatty substances obtained from all three of the kingdoms of matter. The general properties of the substances called wax may be stated thus: They are solid or semisolid substances; are easily broken when cold, but at a moderate heat are soft and pliable, and fuse at a temperature below 212° F. They have a peculiar glistening appearance, are lighter than water, are insoluble in that fluid and in cold alcohol, but dissolve readily in ether; they are combustible, burning with an illuminating flame, and are non-volatile. Beeswax is an animal secretion formed by bees from sugar, and is the material of which the honey-comb is formed. It is obtained by expressing the honey and fusing the residue in water. In this state it is of a yellowish color (Cera flava). It may be bleached, so as to form white wax (Cera alba), by being exposed in thin slices to the action of solar light. The yellow wax is firm, breaking with a granular fracture, melts at about 175° F.; is insoluble in cold alcohol, but dissolves in oil of turpentine, ether or chloroform. It is of a complex formation, and a number of derivatives are obtained from it. $C_{48}H_{92}O_2$ is considered as its general composition. Vegetable wax may be obtained from several varieties of plants, but has no place in casting waxes. Mineral wax is a natural material known as "ozocerite," and is a waxy translucent mixture of paraffins of coal formations The paraffins have a chemical formula of $C_nH_{2n}+_2$. The manufactured mineral wax (paraffin) is a by-product of the distillation of coal and petroleum, and is used in combination with beeswax for casting waxes. The form of wax often used in the dental laboratory known as sticky wax is a combination of waxes and a resin. Such waxes should never be used in forming wax models for metal castings, as the resinous gums leave a residue from the disappearing wax model that is detrimental, producing a roughened surface upon the metal casting. Casting waxes are combinations of hydrocarbons and can be entirely dissipated by heat. Any wax that leaves a residue should be discarded for another. The residue left from the disappearing wax is a carbon compound, and is detrimental to the metal casting, especially those of aluminum. Often when an aluminum casting is taken from the investment an odor of garlic may be noticeable. The student may suspect arsenic. However, arsenic is not an associate of aluminum, but the odor is evidence of the action of a carbon compound upon the metal; and if the surface of the aluminum is burnished, in the finishing process, it will be found pitted. This odor implies that a change of wax or technic is indicated.

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[1] The student can find a most excellent discussion of investment compounds, waxes and fluxes in Peeso's Crown and Bridge-work, Second Edition, Lea & Febiger, Publishers, Chapter XVIII, written by Louis J. Weinstein.

Casting waxes may be tested by melting a portion of the wax upon a slab of investment compound and then gradually heating the slab to a dull red heat without permitting the waxed surface to come in contact with a flame. The wax that leaves the cleanest surface is the preferable wax for metal castings. The casting waxes are put up in calendered sheets of thickness of 32 to 16 (B. & S). gauge. The thin wax is for gold and the thick for aluminum.

Fluxes.—The noble metals have the undesirable property of occluding the oxides of the base metals thereby causing the noble metals to become sluggish, dirty and degenerate. Some of the salts of the alkaline metals, as the borates and carbonates, have a much stronger affinity for the oxides of base metals than has the noble metals, therefore they are used to flux the noble metals and for cleansing or washing out the occluded oxides. These salts of the alkalies are called fluxes. No alkaline flux is suitable for aluminum as it is a base metal and itself soluble in the alkaline metals. Hence aluminum that has been melted repeatedly is too dirty and sluggish to make a good casting and should be discarded. There are no alloys of aluminum that have proved successful for denture castings. The purest metal only should be used. The alloyed metal soon disintegrates in the fluids of the mouth, whereas the alloyed gold should be thoroughly cleansed with and after every fusion. Copper is the one base metal that is used in the gold casting metal, and is most valuable as a constituent, but its oxide is detrimental as are all other base metal oxides that have an affinity for the noble constituents. It seems to the writers illogical to use iron oxide in an investment compound because of its affinity for both gold and aluminum.

Aluminum as a Casting Metal.—*Physical and Chemical Properties.*—It is a silvery white metal with the following properties: Sp. gr., 2.55; fusing-point, 657° C., or 1215° F.; specific heat high, lineal expansion exceeded only by zinc and lead, thermal conduction between gold and zinc, good tensile strength, very flexible, almost no elasticity, about as hard as copper, nearly as ductile as copper, and nearly as malleable as gold. It is electropositive to all other metals used in the mouth, therefore the metal is destroyed if a voltaic couple is formed. This property and a lack of rigidity unfits it for partial dentures. The impurities of aluminum are iron and silicon. The Aluminum Company of America gives the composition of their No. 1 grade as: Silicon, 0.30; iron, 0.15; aluminum, 99.55 per cent. Also their No. 2 grade as containing 2 per cent each of silicon and iron. Its natural solvent is hydrochloric acid; the other mineral acids have little or no action upon it. Solutions of caustic alkalies, chlorine, bromine, iodine and hydrofloric acid act readily and corrode the metal. It withstands the action of organic secretions better than does silver. Therefore it is used for dentures, for surgical instruments, and for articles subjected to carbolic acid or other organic antiseptic solutions; but solutions of mineral salts should not be used upon it. It is not injured perceptibly by the salt and vinegar used for culinary purposes.

The first casting of aluminum base-plates is credited to Dr. J. B. Bean of Baltimore in the sixties of the last century, but the method was not a success until Dr. D. D. Campbell of Kansas City, Mo., published his "Cow-Bell" centrifugal method early in 1908 in the *Dental Brief*, and at the same time Dr. J. H. Billmeyer of Norwalk, O., published his "Bucket" method in the *Dental Summary*. The difference in the two methods was in the manner of placing the sprues. Dr. Campbell used a triple feed sprue placed at the three highest points, that is, the tuberosities and the margin of the palatal vault. Dr. Billmeyer used one feed sprue attached at the lowest point of the mold, that is, the center of the labial border, and two vent sprues at the high points (tuberosities). Both methods have proved successful. The Billmeyer method seems to the writer to be the more logical and is the one that will be described in this chapter. However, a description of the one is a description of the other except as to the placing of the sprues. The pressure methods and the Brophy Elgin Vacuum method soon followed Dr. Taggart's pressure inlay method of 1907.

Cast aluminum bases should be confined to full dentures, both upper and lower, and to well resorbed processes. In fact the method is almost contraindicated in high peaked vaults and thin flaring alveolar processes, because of the metal's high shrinkage index and difficulty of swaging the cast base so as to overcome the warpage. In the opinion of the writer there is but one place in which an aluminum plate either cast or swaged is indicated, and that is as an intermediate between vulcanite and a gold or a continuous-gum denture.

There are two general methods for making castings, known as the Direct and the Indirect. The direct method consists of luting the wax model denture-base to the original cast of the mouth and flasking the two together, thus destroying the original cast in producing the metal casting. The indirect method consists of removing the wax model denture-base for its casting, and thus saving the original cast for future use. It is self-evident that the indirect method is the preferable one when the wax can be removed from the cast without distortion. Unfortunately there are too many cases that cannot be drawn without unavoidable distortion. The cast for the direct method must be made of the investment compound, while the cast for the indirect method should be made of any one of the modern cast materials.

The wax model base-plate for an aluminum casting should be made similar to the method described for the tin casting, only it should be formed of the best casting wax obtainable. The wax should be 18- or 16-gauge thick or two thicknesses of 24-gauge. In the opinion of the writer the thin casting advocated by some is a mistake because the cast metal is crystalline in structure and requires greater bulk for the same rigidity that the rolled metal swaged would have. Good engineering requires that any construction shall have sufficient body to resist successfully any stress to which it may be subjected; and it is evident that these light castings are too often a failure soon after being subjected to use.

Technic.—The technic for a pure aluminum cast base consists of an impression, a cast of investment compound for the direct method or of hard plaster compound for the indirect method, a suitable wax model, flasking, heating, melting of metal, casting and finishing.

Impression.—If the impression is of plaster it should be prepared by carving, if there are hard places needing relief in the finished denture, and then coating with thin shellac followed, when dry, with one or more coats of thin sandarac. No other separator gives so desirable a surface to the cast as shellac and sandarac applied separately. The impression should be boxed in so as to permit thorough jarring in of the cast material.

Casts.—For the direct casting method the cast should be made of the investment compound preferably of a high grade silica compound. Too much care cannot be taken in forming the cast so as to give it a smooth glazed surface. For the indirect method any one of the newer "artificial stone" cast materials may be used. The writer prefers Healy's Artificial Stone or the Ransom and Randolph Model Stone (Improved).

Wax Model Base-plate.—The object sought in forming the wax model for a cast aluminum base-plate is to so place the material that the finished product shall have at every part sufficient body to resist the stress to be placed upon it; to form square joints, thus no feathery edges of either vulcanite or metal; and to provide for securely attaching the teeth by means of vulcanite to the base-plate.

Technic.—A sheet of heavy (16 gauge) casting wax is warmed and evenly adjusted to the cast, the excess is cut away with a warmed wax knife, or a very sharp lance carving instrument, and the edge at several points luted to the cast. It is evident that the thickness of the sheet of base-plate wax will control the thickness of the casting, therefore a wax of suitable thickness to produce the desired result in the polished plate must be used. The additions to the wax base-plate are made by the use of rolls made of the casting wax by a wax sprue former (Fig. 451), using the largest size nozzle or without any attachable nozzle. The wax roll may be formed, but more laboriously, by rolling the softened casting wax upon a clean smooth surface, using a piece of glass to press and roll it. A slab of glass one-fourth by three by six inches ($\frac{1}{4}$ x 3 x 6 inches) is suitable for rolling the wax. The large roll of wax should be approximately $\frac{1}{8}$ inch in diameter. The roll is warmed slightly and conformed by the fingers to the buccal and labial borders of the wax base-plate, and the lingual portion of the alveolar process outlined. Necessarily judgment must be exercised in placing the roll of wax so that its substance will give the desired contour to the model base-plate. Fig. 459 shows the base-plate wax adjusted and the peripheral wax as adjusted by the fingers. The roll of wax is contoured and united to the base-plate by using a hot ironing spatula. The wax should be formed so as to present a square edge and thus, a butt joint between the vulcanite and metal. A thin feathery edge of either vulcanite or metal is undesirable. The next step in forming the wax model is to make provision for securely holding the vulcanite attachment to the metal casting. This is best done by means of a row of cleats as near the edge of the union of the vulcanite and casting as it is possible to place them. These cleats are formed of sprue wax of about 16 (B.&S.) gauge. The small-sized nozzles and sprue former are best for this, or a piece of the large roll may be warmed and reduced by rolling under the glass slab. The wax is bent into a series of loops, placed upon the model base-plate as near the periphery of the desired union of the vulcanite and metal as possible. The points of contact upon the base-plate are luted by a touch of a hot wax spatula.

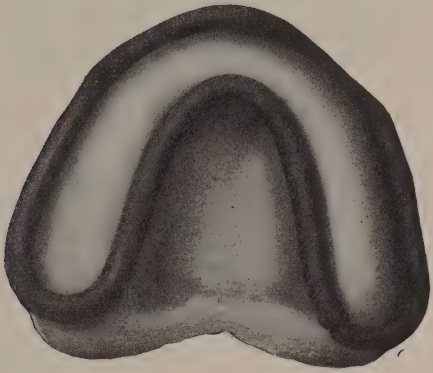


FIG. 459—Base-plate with peripheral wax adjusted.

When the wax is cold the tops of the loops are cut away with a pair of small curved scissors. Fig. 460 shows the peripheral wax attached, the looped wax upon one side and the sheared loops completing the cleats upon the other side. The completed wax model plate is prepared for flasking by attaching gate or sprue formers. These are one feed or pouring sprue and two vent sprues. The feed sprue former is a roll of casting wax which must not exceed $\frac{3}{16}$ inch in diameter, attached near the lowest part of the wax model, as it is to stand in the flask. It is obvious that the larger the feed sprue hole the more quickly the mold may be filled with the molten metal; and the smaller the sprue hole the more danger of an incomplete casting from the metal chilling. However, as the feed sprue hole connects with the bottom of the melting crucible, there is a limit to its size. This limit for safety has been found by practice to be $\frac{3}{16}$ inch. A sprue of $\frac{1}{4}$ inch diameter is almost certain to permit the first molten metal to fall into and clog the lower end of the hole, thereby preventing the filling of the mold. The explanation of this fact is that the specific gravity of the metal resting over a $\frac{1}{4}$ inch diameter hole is greater than the cohesion of the molten metal. The vent sprue formers are 14- or 16- (B. & S.) gauge iron wire attached to the highest points of the wax model.

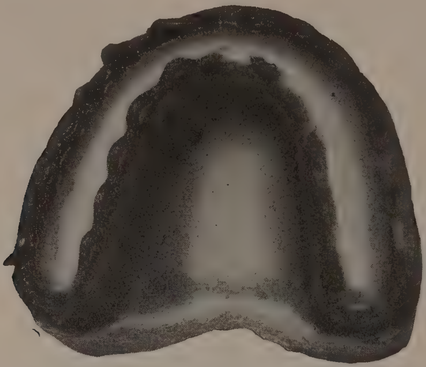


Fig. 460.—Base-plate with peripheral wax attached.

Flasking.—The wax model is first invested and then flasked. If the direct casting method is to be used, the wax model is thoroughly luted to the cast, and then coated over with a thin mix of the investment compound, applied with an ox-hair brush, lapping it well upon the cast. As the investment begins to set it may be poured on from a spatula at those places needing special support, as the sprues and cleats. For the indirect method the wax model is luted only at two or three points, just enough to hold it in place, and then the outside invested the same as for the direct method, only the investment must not lap upon the cast. When the investment has set sufficiently to have good rigidity, the luting wax is freed with a sharp lance knife, when the partially invested wax model is carefully removed from the cast and the inner surface is invested in the same manner as the outer surface, permitting the investment to lap well upon the outer investment, and then permitted to stand until the new investment is set enough to handle safely. Fig. 461 will represent the wax model and sprues invested for either the direct or indirect method for casting.

Fig. 462 represents a sheet iron bucket. The handle and bail are removed for flasking and heating.

The Cow-bell method uses a Hoosier cow-bell with two holes drilled near the edge of the flange for inserting the hooks of the bail for casting.

For flasking, with either the bucket or bell, the flask is two-thirds filled with moderately thick investment compound and the invested case, dipped in water, is pressed into the soft investment until it nearly

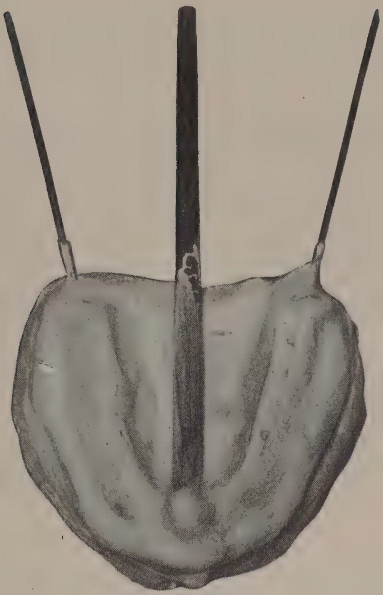


FIG. 461.—Wax model and sprues invested.

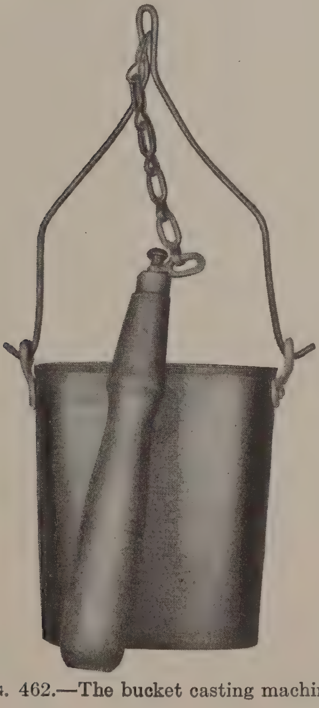


FIG. 462.—The bucket casting machine.

reaches the bottom of the flask. At the time of settling the invested case into the flask, the flask should be so grasped that it can be carefully jarred upon the bench, thus excluding all air. When the investment has partially set, a cavity is carved about the wax casting sprue for a melting crucible (Fig. 463). When the investment has thoroughly set the inside of the crucible mold is scraped smooth with a round-end

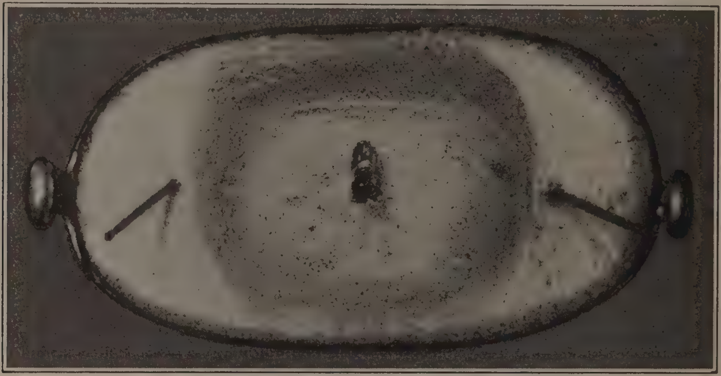


FIG. 463.—Carved crucible.

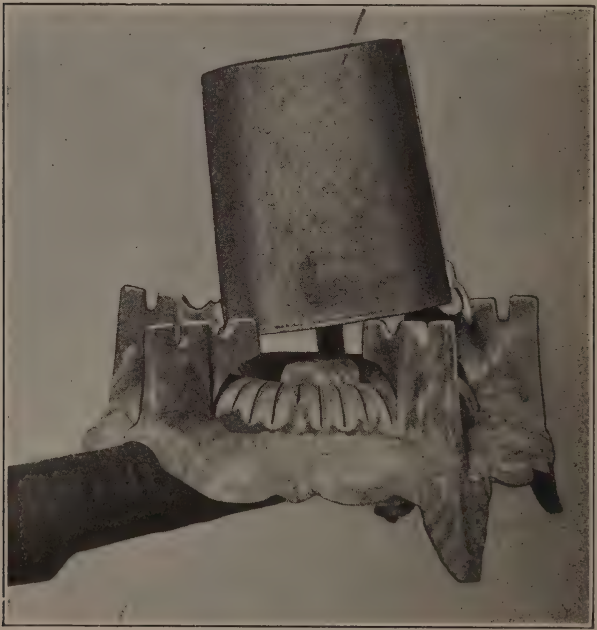


FIG. 464.—Melting out the wax.

vulcanite scraper. This will leave the wax sprue former just flush with the floor of the crucible. All particles of loose compound must be brushed or jarred out. The flasked case is placed in a warm place (not in an open flame) to dry and soften the wax; as soon as the wax begins to run, the vent sprue wires are drawn and the case inverted upon the gas stove (Fig. 464). As the wax of the model melts it either ignites or drops upon the bench. There should be no smudge of burning wax if it is in direct contact with the flame, as the carbon, hydrogen and oxygen are so proportioned in wax that it burns smokeless under favorable conditions. For the first ten or fifteen minutes the gas is turned on about one-half and then for the rest of the heating up it is on full. The flask should be heated in the inverted position for one hour, or until there is no flame issuing from the feed sprue hole, thus signifying that the wax is completely burned. The flask is reversed, that is the small end is down for half an hour. Heating for another half-hour will do no harm, but it is unnecessary.

Aluminum for Casting.—The purest aluminum obtainable should be used and in quantity twice the amount needed to fill the mold. The excess metal is necessary to provide for a head of molten metal to aid in exerting pressure and to be absolutely sure that no dross is forced into the mold or to interfere with the free flowing of the metal. The quantity required is estimated by one of two methods: First, experienced guessing; second, weighing.

Weighing.—The specific gravity of wax is 0.96, and of aluminum 2.56; therefore, the aluminum casting will weigh two and two-third times as much as the wax model, and the weight of metal required should be at least five and one-third times the weight of the wax model.

Caution. Aluminum absorbs its oxides and occludes gases, therefore, it is better never to remelt metal for casting that has acquired even a slight yellowish tint.

Melting the Metal and Casting.—Before placing the metal into the melting mold or crucible, the upper portion of the flask including the crucible is thoroughly heated with a large blue flame of the blowpipe. This precaution is to assure that the upper end of the mold is sufficiently heated, thus avoiding the granulated effect sometimes seen in this portion of the casting. The metal is placed in the crucible and a yellow-tinged flame of the blowpipe played upon it until it is thoroughly melted, as indicated by the nugget of metal settling upon the floor of the crucible, although the upper surface is spheroidal. The metal has high specific heat, therefore no need for undue haste, but no time should be wasted in getting the metal cast. The gas is turned off the gas stove, the bail is attached to the bucket, and as it is lifted from the stove the chain is made straight. The swinging of the bucket is started with a steady long swing, avoiding a jerk at the start of the swing. The diameter of the swing is quickly reduced to the limit and the speed increased. The motion should be continued until the metal has crystallized. This will probably require from 50 to 100 revolutions.

Philosophy of the Casting Process.—By the swinging motion centrifugal force drives the molten metal down the feed gate into the mold. By the law of physics (that liquids seek their level) the molten metal will rise in the mold and vent holes until it is on a level with the head of metal, when the centrifugal force will condense the metal until the hardness of the crystals of metal and centrifugence are equal. This will probably be when the metal has cooled 50 to 100 degrees below its fusing-point. It is reasonable to suppose that the metal that has travelled the farthest from the head of metal will be the first to set, therefore as the vent sprues and the palatal border chill, any contraction that is taking place will be made good by the molten metal under pressure backing it up, thereby keeping the mold full and providing a well fitting base-plate. The writer, by careful visual observation, has not been able to detect the defects in the castings made by this method that have been noticed in the castings made by other methods. Therefore the writer confidently presents the foregoing method as most excellent for casting aluminum. However, the Billmeyer method for placing the sprues is not suitable for gold or metals of high specific gravity.

Suggestion.—Sufficient free space must be provided for swinging the bucket, and expertness in swinging must be acquired by the operator before attempting molten metal. Experience in swinging may be acquired by practicing with a small bucket of water. A further suggestion is that the walls of the crucible should be quite perpendicular, not flaring.

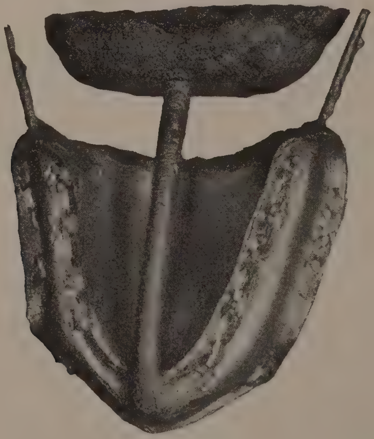


Fig. 465.—Casting removed from investment.

Cooling and Removing the Casting.—After swinging, the casting bucket should be permitted to stand in a cool place for at least fifteen minutes, after which the cooling may be expedited by submerging in cold water. A plaster spatula is passed between the flask and investment, when by pressure upon the loose bottom of the bucket the casting and investment will be pushed out of the bucket. The investment is broken and brushed away from the casting. Fig. 465 shows the casting as it comes from the investment. The sprues are snipped away and the edges filed. The case is sandpapered and buffed with felt and pumice the same as vulcanite.

Caution.—Cast aluminum is not elastic, therefore care must be exercised in manipulating light castings not to bend them. Probably more castings are warped by bending than by improper casting. Fig. 466 shows a trimmed and buffed aluminum base-plate.

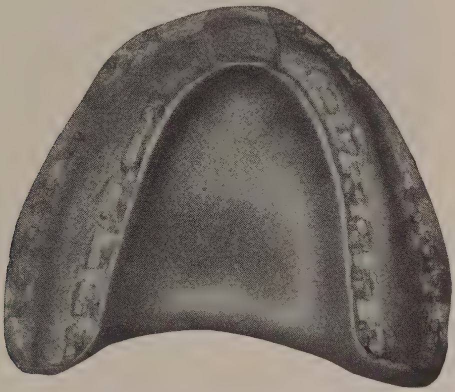


Fig. 466.—The trimmed cast base-plate.

Use of Aluminum Base-plate.—The aluminum base-plate is to be used the same as the vulcanite base-plate for obtaining the occlusion and contour wax models, mounting on the antagonizer (articulator), setting up the teeth, proving the antagonization and contour, flasking, packing, vulcanizing, and finishing.

All of these procedures as described for vulcanite work are sufficient for the work in hand, except flasking and polishing.

Flasking.—The aluminum base-plate should be so embedded in the first half of the vulcanite flask that as little of the metal will be exposed as possible; thus avoiding the scraping of vulcanite from the buffed surface. Fig. 467 shows an upper case suitably encased in the lower section of the vulcanite flask.

Polishing.—Aluminum may be scraped the same as vulcanite but it may be dressed down easier with the emery cloth band on the lathe arbor (Fig. 468). The lathe should be run at high speed, and light pressure used in holding the work against the abradant. Scratches are removed from the surface by the use of felt buffers and pumice, followed with a soft brush and whiting. This gives the aluminum a leaden polish due to fine particles of the metal and abradant being ground into the surface of the metal base-plate. There are three methods of cleaning and developing the luster of aluminum: (1) Chemical, (2) use of special polishing preparations, and (3) burnishing. The chemical method consists of treating with caustic alkali and acids alternately. This method is hardly suitable for the dental laboratory. However, it gives a beautiful frosted effect, but it is doubtful if it is desirable.

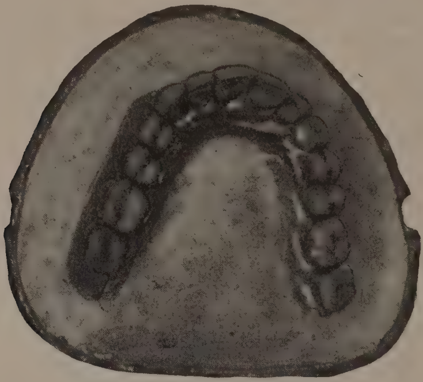


Fig. 467.—Upper case in flask.

There are several preparations useful for the second method. Benzene and whiting rubbed on with a buffer of cotton or chamois-skin, or these materials used by hand. A paste may be made of 2 drams each of copper sulphate and potassium carbonate and 1 ounce of lard. To this paste add 1 or 2 drams of any one of several finely ground abradants as chalk, rotten stone, rouge, tripoli, or buckhorn.

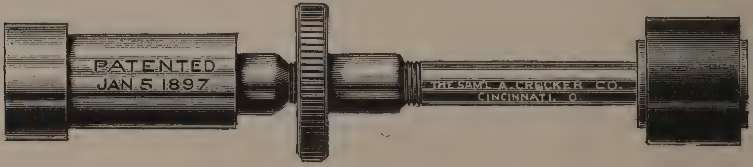


Fig. 468.—Emery cloth for dressing down aluminum casting.

The burnishing is done with an agate or bloodstone burnisher and a burnishing fluid composed of equal parts of olive oil and rum. This method is the very best for the maxillary and mandibular surfaces, but is open to the objection that it shows up the unequal hardness of the dressed surface. However, it produces the hardest and best wearing surface of any of the methods of finishing.

Figs. 469 and 470 show views of completed dentures on aluminum base-plates. Fig. 471 shows the lingual surface of a denture with the metal cast to the teeth. Figs. 472 and 473 show the same case as the casting came from the flask.

Casting to Porcelain Teeth.—The wax model must be so shaped that the cast metal will not overlap any edges of porcelain, because the contraction of the cooling metal may crack the porcelain teeth. The lingual surface of the denture must be carved to shape in the wax and smoothly finished. Chloroform can be used to finish the wax surface. The flasked case should be made very hot before pouring the metal; and then the case must stand until it is cold before removing from the

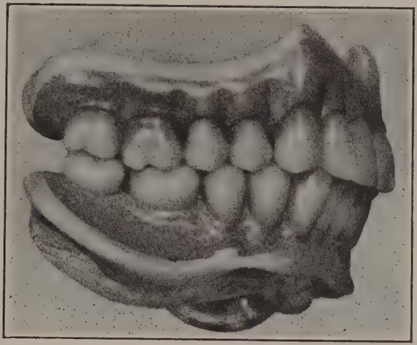


FIG. 469

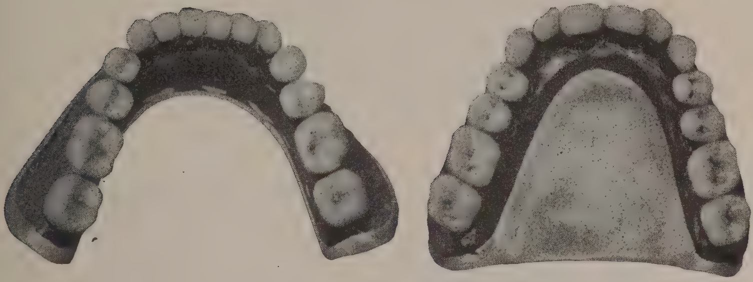
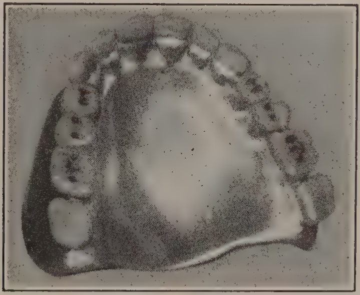


FIG. 470



FIGS. 467 to 471.—Completed dentures on aluminum base-plates.

investment. Platinum pin teeth should not be used, as the molten aluminum is a solvent for platinum. The labial and buccal surfaces are finished with vulcanite. Casting to the teeth is of doubtful expediency.

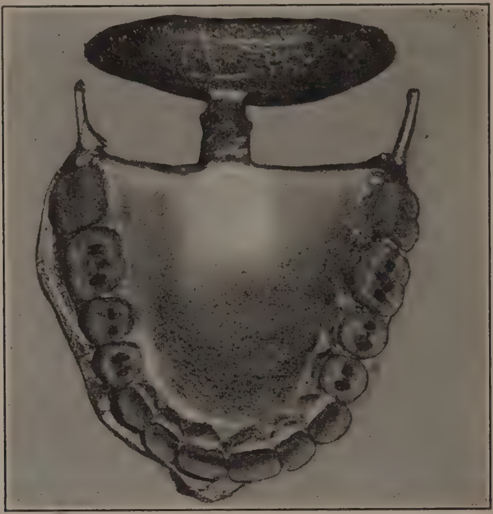
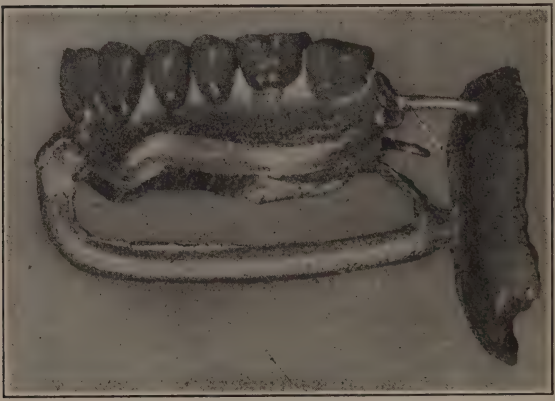


Fig. 472



Figs. 472 and 473.—Case shown in Fig. 471, as it came from the flask.

The Hollenback Unit.[1]—This machine is probably the best illustration of a casting unit, incorporating the centrifugal force and cold mold principles, before the profession. It is a compact, simple and easily operated device. The oven is designed for drying out the investment for cold casting of inlays and clasps. The cold mold method is not suitable for castings larger than clasps and saddles that can be produced in the small-sized casting ring. The oven has a tray upon which one to five cases may be dried at once (Fig. 474). The electrical units are placed upon each side of the tray and are regulated by a thermostat so that a temperature under 400° F. is constantly maintained for one and a half hours. In about one hour after the wax pattern is invested the flask is placed upon the oven tray with the sprue end downward. As the wax pattern melts the excess water of the green investment washes out the wax, and does not permit of any appreciable absorption of the wax by the investment compound. When the investment is perfectly dried the flask may be set aside and the casting made at any convenient time. However, the casting should be made before the investment absorbs moisture from the atmosphere.

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[1] This machine is an invention of Dr. G. M. Hollenback, and is manufactured by the Occidental Mfg. Co. of Los Angeles, Cal.

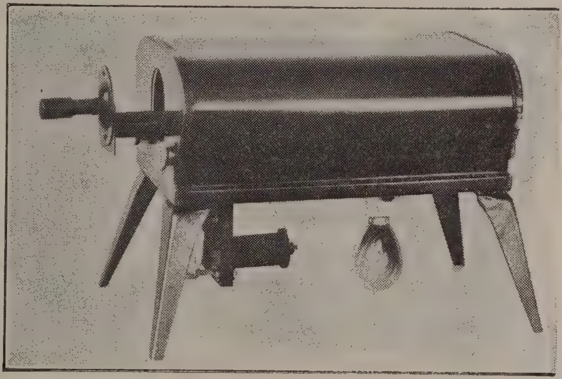

Fig. 474.—Hollenback drying oven.

The casting apparatus is operated by a spring and release lever, therefore is uniform and reliable in action. The crucible is made of fire clay and is easily replaceable. It is impossible for any of the molten metal to enter the mold before the spring is released; and the molten metal can be suitably fluxed without danger of the flux entering the mold (Fig. 475). The parts of the casting portion of the unit are so placed that the least possible heat is applied to the mold. The result is that a bright, clean, perfect fitting casting is produced, after cleansing in hydrochloric acid.

The large flask is for saddles and the various sections of a partial denture that are too large for the small flask. The wax pattern is carbonized and burned out and the casting is made in the hot flask.

The vacuum method is well illustrated in the Elgin Vacuum Casting Machine shown in Fig. 476. The technic for forming the wax model for this method and machine differs from that described for centrifugence only in placing the sprues. This method admits of no vent sprues, but the feed sprue, either single or multiple, must include all the high points of the mold; so that every portion of the mold may be filled by a downward flow of the metal, the air having been drawn from the mold through the porous investment by means of the vacuum pump. Fig. 477 shows a casting and the excess metal attached made by the Elgin machine.

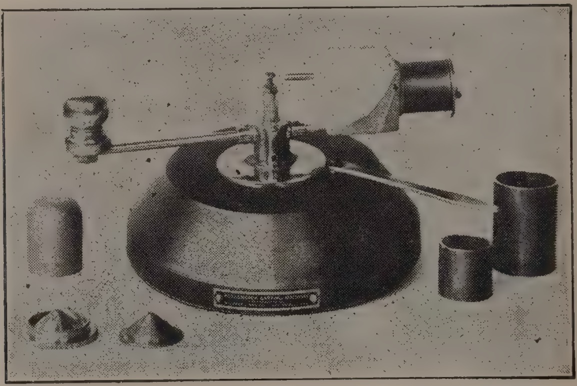

FIG. 475.—Hollenback casting machine.

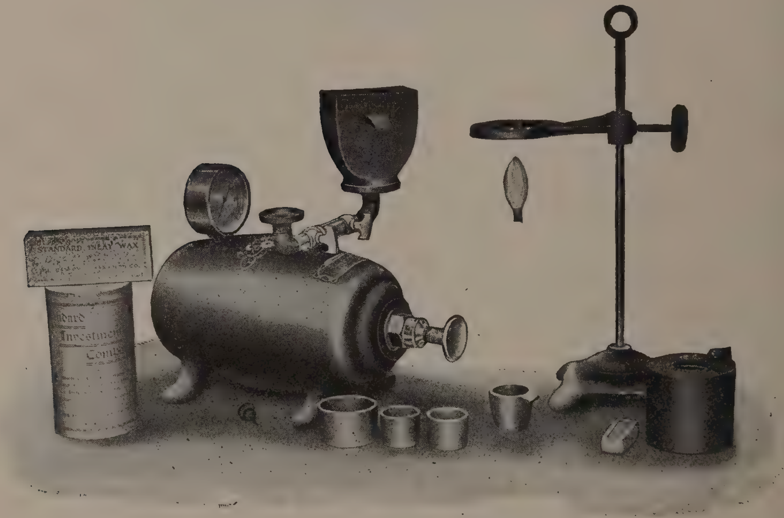

FIG. 476.—Elgin casting machine.

Pressure Method and Machines.—The gravitation method for making dental castings preceded the pressure principle only; but neither principle met the universal approval of the profession until Dr. W. H.

Taggart demonstrated his methods in 1907. His was the first successful machine for using the pressure principle, and it is regrettable that the machine is not upon the market at the present time. However, recently two very excellent casting machines of this type have appeared; the machine of J. E. Burns (Fig. 478), Flushing, Long Island; and the Alston Improved Metal Casting Outfit by The Dental Manufacturing Co., Ltd. (Fig. 479). Both of these machines are equipped with compressed air attachment and regulator, or, when desired, a tank and

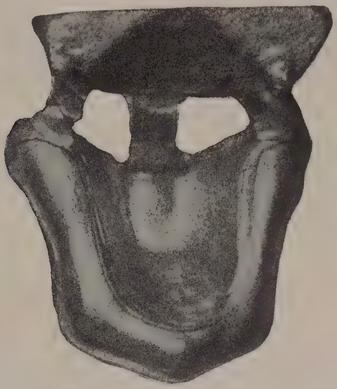

Fig. 477.—Casting made with Elgin machine.

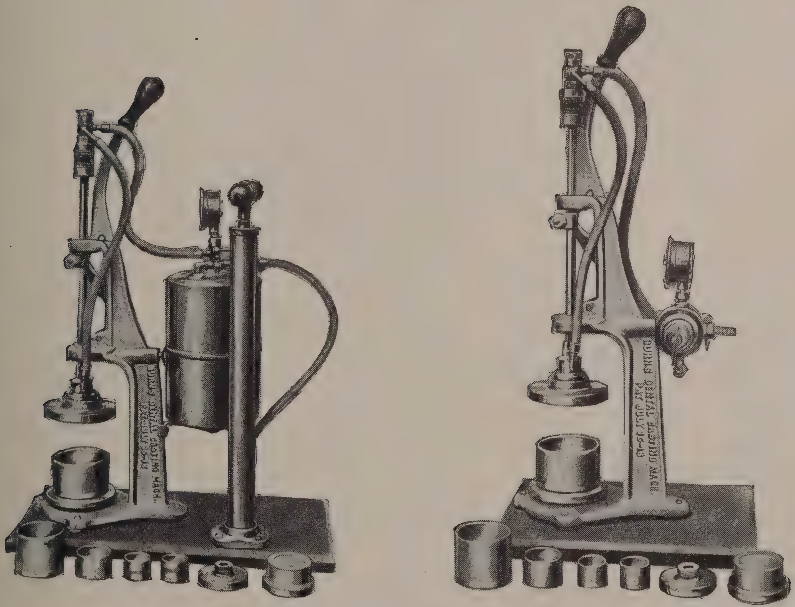

Fig. 478.—Burns' casting machine.

hand pump. The writer is of the opinion that the pressure principle for casting is the most universally successful and the one that will stand the test of time. However, any of the methods are applicable when the details are mastered.

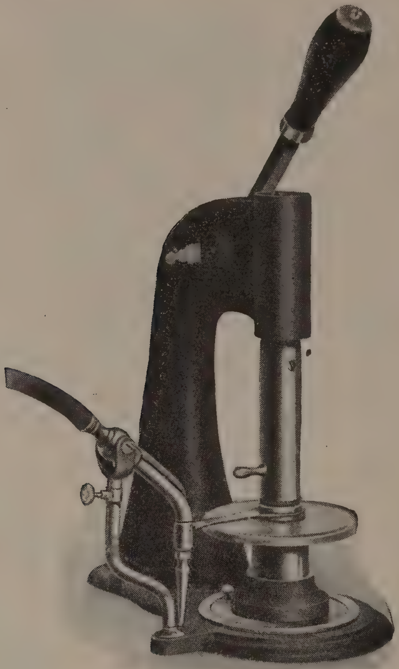

FIG. 479.—Alston casting machine.

Gold as a Casting Metal.—*Physical and Chemical Properties.*—Pure gold is a bright, rich yellow, noble metal, with a specific gravity of 19.3, varying in its fraction according to the method of reduction and form. Its fusing-point, as given by the U. S. Bureau of Standards, is 1945° F. It is the most malleable and ductile of the metals, fifth in tenacity, and third as a conductor of heat and electricity. It is nearly as soft as lead and can be alloyed with many of the other metals. It is insoluble in any of the ordinary mineral acids, but soluble in nitrohydrochloric acid.

Pure gold is not suitable for casting for any part of denture construction, but must necessarily be made harder, more rigid, and for certain uses, as elastic as possible. The metals suitable for alloying the gold for casting are silver, copper, platinum and palladium. Silver is used chiefly to modify the color; copper is used to give hardness and elasticity, it reduces the fusing-point of the gold markedly and deepens the color; platinum is used to increase the hardness, elasticity and raise the fusing-point; palladium is used to add the same properties as platinum and is better than a high percentage of platinum, as it unites more uniformly with the gold and weight for weight raises the fusing-point of the alloy more than platinum; however, palladium destroys the gold color, reducing the mass to the color of platinum. The high fusing and elastic gold alloys are restricted, therefore, to bands, bars and clasps.

The Ney-Oro golds made from the formulæ of Mr. Louis J. Weinstein are undoubtedly the most uniform and scientific casting golds upon the market. Further than this their formulæ are published; therefore they are ethical and professional material. The dentist knows what he is using and can use the Ney-Oro golds intelligently, which cannot be said of any make of gold the formulæ of which is not published. These golds may be melted with the gas and air blow-pipe, but are more suitable for the gas and oxygen or nitrous-oxide blowpipe. Care must be used to thoroughly melt, but not to overheat or burn, the gold. This implies that a sufficient illuminating gas flame is used and not an excess of oxygen forced into it, but enough to accomplish the desired result.

The Ney-Oro casting golds that will meet every requirement are the following:

	"C" Per cent.	"B" Per cent.	"E" Per cent.
Gold	80.5	80.0	64.0
Platinum	6.5	9.5	11.0
Palladium	2.0	2.5	16.5
Silver	2.0	1.0	1.5
Copper	9.0	7.0	7.0
Total	100.0	100.0	100.0
Fusing-point	1800° F.	1975° F.	2100° F.

Ney-Oro "C" is suitable for cast full dentures and saddles that are to be reinforced. It should be melted with the gas and air blowpipe only. Ney-Oro "B" is designed for any full or partial denture requiring greater rigidity, with less bulk, than can be attained with "C." This gold can be properly fused with the gas and air blowpipe provided the operator is expert and the mass of metal is not too great. Ney-Oro "E" is suitable for clasps, bars, bands and any part where the greatest rigidity is required. This gold may be melted in small quantity with the gas and air blowpipe, but it can be better manipulated with the gas, and oxygen or nitrous-oxid blowpipe, when any quantity desired can be properly fused.

Investment Compounds for Gold Castings.—It is the opinion of the writer that the liquid graphite investment is better adapted to small castings as clasps and small saddles, but that large saddles and full dentures can be better manipulated with the silica compounds, because of their greater strength and porosity. However, either class of material may be used universally. It is the opinion of the writer that better results are obtained by using either one alone than by using both in the same flask.

General Suggestions for Gold Castings.—The best results seem to be obtained from "green" molds, that is, where the investments have not been permitted to dry out by long standing; therefore, the indirect method gives smoother and better results than the direct. However, if the original cast is used and it has become thoroughly dry, then it should be thoroughly soaked in water before adding more investment, also before heating up if a flasked case has stood for a day or two. This suggestion is thoroughly empirical, for the writer is not satisfied with any explanation he can offer.

If the casting table of a pressure machine is not recessed, a shallow recess should be cut in the investment to aid in the escape of gases while casting.

Too thin casting wax should not be used thereby avoiding imperfect or weak castings. Use 16-gauge (B. & S.) sprues and a sufficient number to fill every part of the mold promptly.

Use clean metal for each melting. If the metal has been previously used, clean it with reducing flux and acid.

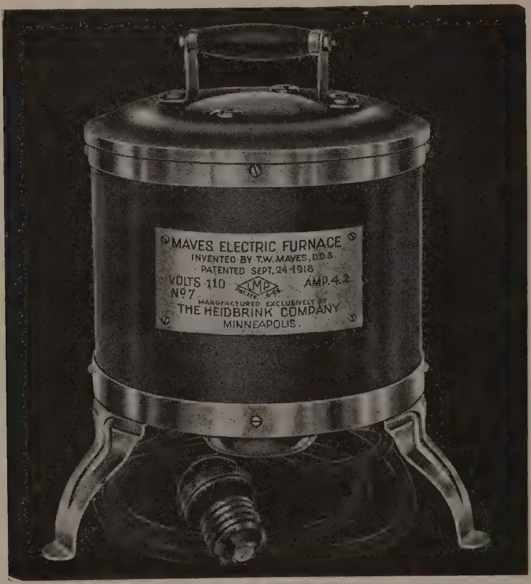

FIG. 480.—Maves heating furnace.

Heating the Flask.—All cases should be warmed slowly so that the wax model may be absorbed by the investment, if a small one, and partially absorbed if a large one, when the flask can be inverted and the excess of wax permitted to run out of the sprue holes. The heat is gradually increased until the mold is thoroughly dry of wax and moisture. The mold is now known as a cold mold although it may be a few hundred degrees hot. The cold mold is desirable for clasps and very small saddles, but for large castings and where the molten metal must flow some distance the mold must be hot, red hot. The smallest size casting flasks may be sufficiently heated in a Maves Furnace (Fig. 480) in thirty-five or forty minutes, but the next size flask will require fifteen to twenty minutes longer, while the large size flask will require from one to two hours in the open flame. Do not attempt large castings in a cold mold.

Pressure Required for Casting.—Very small castings will require 8 to 12 pounds pressure, and medium to large castings will require 15 to 20 pounds pressure.

The investment compound must not quite fill the top of the flask. There must be at least $\frac{1}{16}$ inch of free flange to permit the flange bedding itself into the asbestos packing of the head of the casting machine. Sufficient force must be applied and sustained upon the closing lever to prevent escape of the compressed air. Necessarily the larger the perimeter of the flask the greater the pressure to make a tight joint between the flange and packing.

Making the Wax Model for Casting Gold.—For the direct method of casting the investment compound cast needs no preparation; but for the indirect method the hard plaster cast should be slightly lubricated with sweet or sperm oil, or the surface may be sprinkled with soapstone, which should be well rubbed in, and the excess brushed away. The cast may be slightly warmed, but not above 100° F. The casting wax may be sufficiently warmed by holding for a moment between the palms of the hands and adjusted to the judiciously warmed cast. Extra heat is best applied by warming the thumb or hand rather than by exposing the wax to direct heat. However, to warm the wax by direct heat of the flame hold the case several inches above the flame. For the indirect method the wax must be perfectly molded to the cast and luted at a few points only. Portions of the surface may be doubled by the same careful warming and conforming of the added wax. Round wax attachments are more safely attached by luting with melted wax carried on a small spoon as the No. 1 Evans' wax carver. The wax sprue formers should be approximately 16 (B. & S.) gauge in size, the second size of the wax former. Often these feed sprues can be so attached that they will also form the cleats for the vulcanite attachments. Judgment must be used to place a sufficient number of sprues to quickly and perfectly fill the mold. A clasp will require one feed sprue, with possibly an auxiliary, as shown in Fig. 481. Saddles will need two or more and a full denture may need eight or ten wax sprues (see Fig. 482). These sprues must all have separate openings into the floor of the melting crucible (see Fig. 483). They must be so placed and sufficient metal used so that they are all covered with the molten metal until the mold is perfectly filled. Should a single one of these feed sprues be exposed to the compressed air the casting will be spoiled.

Investing and Flasking.—The wax model is first invested and then flasked as already described under aluminum.

Partial Dentures.—Partial dentures are best cast in units and the units united by soldering. A unit is a clasp, saddle or a connecting bar or band. Two saddles can be joined with a bar by lap joints better than by butt joints. There is necessarily shrinkage in casting; however, this can be largely compensated by sectional castings and lap joints. (See Fig. 484.)

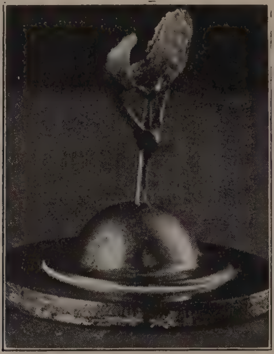

Fig. 481.—Clasp with lead sprue and auxiliary sprues attached.

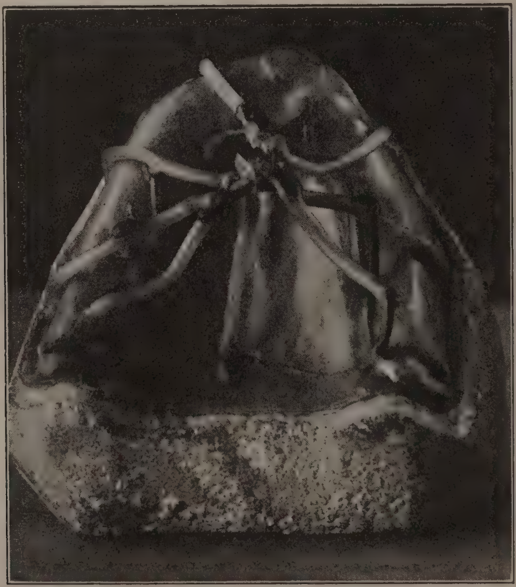

Fig. 482.—Saddles with sprues attached.

Fig. 485 shows the five units—two clasp units, two saddle units and the connecting unit—united.

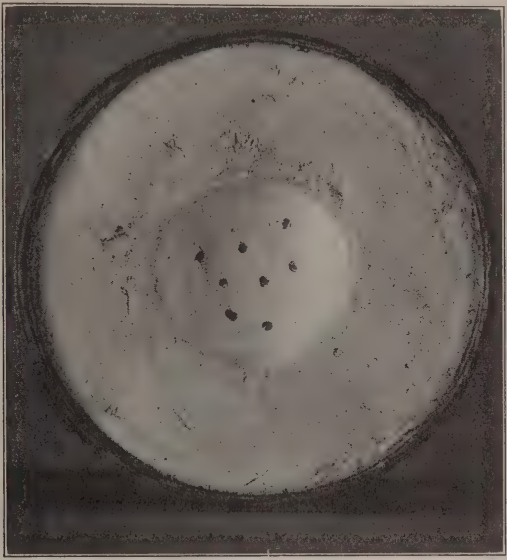

FIG. 483.—Crucible openings leading to several sprues.

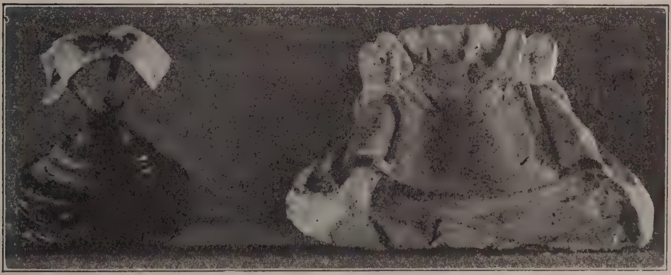

FIG. 484.—Sectional castings with lap joints.

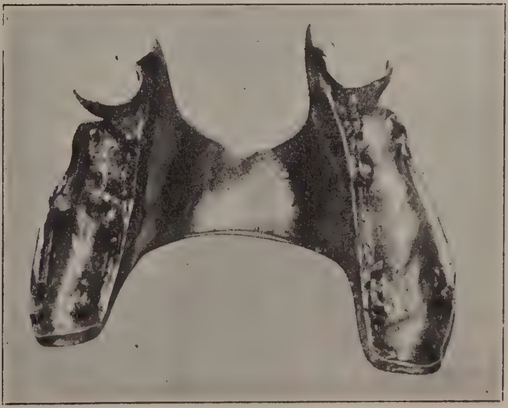

FIG. 485.—The five units united.

Swaging Cast Dentures.—The casting may be swaged, often with advantage. The Parker Shot Swager (Fig. 486), or a similar swager may be used. This method is especially adapted to full dentures. The hard plaster compound cast is centered and set in the base of the swager with a fresh mix of plaster, or with high heat modeling compound. The casting is then placed upon the hard plaster cast, and covered with light weight rubber dam, and a sufficient quantity of low-heat modeling compound to nearly fill the swager is quickly adjusted and submitted to heavy pressure in a screw press; or, it may be struck one dead blow with a heavy sledge (16 pounds). A better way than striking with the sledge is by the drop swage. This is a miniature pile driver. The drop swage has the advantage over the sledge in that it holds the base-plate under pressure until the molecules of metal become set from the vibration produced by the swaging force. Cast aluminum may be swaged in the same manner.

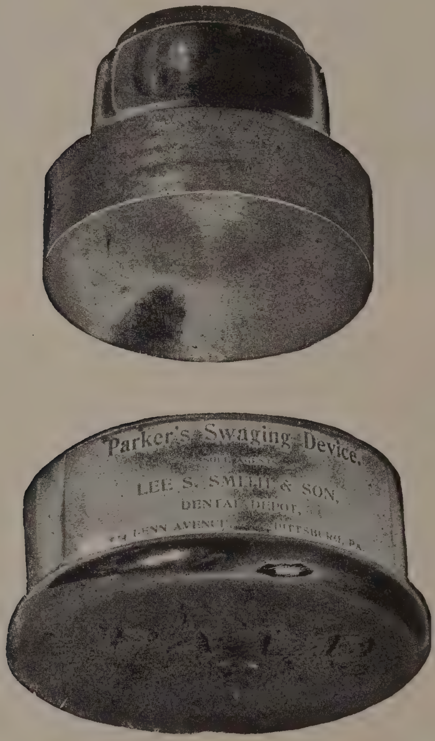

FIG. 486.—The Parker shot swager.

Amount of Gold to Use.—The same rule given for aluminum will serve for gold; therefore multiply the weight of wax by 40. However, for large castings multiplying by 30 will give a sufficiency.

The castings are finished by grinding, filing, buffing and burnishing. Ivory soap is a good lubricant for the burnisher of either steel or stone.

CHAPTER XIV.

CONTINUOUS-GUM DENTURES.

By D. O. M. LeCRON, M.D., D.D.S.

REVISED BY

WILLIAM A. CAPON, D.D.S.

If it be agreed that beside the restoration of function, one of the chief desiderata in the construction of an artificial denture is the imitation of the natural appearance of the teeth and gums, then it may be said that the continuous-gum process offers greater esthetic possibilities than those of any other method of prosthetic restoration. By its means the physical characteristics relating to the appearance of the restored tissues may be so closely imitated as to defy detection at the hands of the most skilled observers.

Continuous-gum takes its name from the fact that when the porcelain used for this purpose is fused upon a platinum base to which specially designed teeth have been attached, a porcelain surface is obtained which is without break in continuity between teeth and gums.

The first conception of the uniting of porcelain teeth to a metallic base by means of a fusible porcelain material originated in France. Among the names of those who first bent their efforts in this direction may be mentioned M. Delabarre, of Paris, who in 1820 used a material closely resembling ordinary porcelain tooth-body to unite the teeth to the plate. Contemporaneous with that of this pioneer, we find the names of M. de Fonzi, who applied jeweler's enamel for the purpose of restoring the contour of the gums, and of M. de Chemant, to whom patents were granted for the manufacture of a form of denture belonging to this type. The work of these early experimenters was attended in a large measure with failure because of the imperfect character of their materials and the lack of knowledge concerning the means for their proper fusing. Experiments with the silicious compounds were abandoned before any satisfactory results were obtained. This was because of the great heat necessary to work the materials used, for, according to Dr. Locke, they required a temperature of 3761° F. for proper fusing.

It remained for an American to realize the object sought by these early French investigators, and by practical researches to rescue from obscurity this beautiful process and place it before the dental profession upon a practical working basis. It was Dr. John Allen, of New York City, who in 1846 perfected a method of construction and compounded a porcelain body upon which he was granted patents in 1851. The priority of this invention was contested by Dr. William Hunter in a suit, accounts of which were published in the dental journals of that time. Dr. Allen surrendered his patents of 1851 because of defects in them, and in 1856 a new patent was issued to him for the process as he had then improved it. This was known as "Allen's Continuous-Gum."

Believing in the possibilities which this process offered, a few men have worked steadily since that time to improve and develop its details, and gradually many of the early sources of annoyance and failure, such as springing of the plate, and checking and scaling of the porcelain, have been overcome. The porcelain bodies now manufactured are, if properly manipulated and fused, sufficiently strong to withstand any legitimate use. It is essential, however, that the porcelain should be superposed upon a metal frame-work constructed with strict regard to mechanical principles. Continuous-gum body of today is a silicious compound, similar in composition to that of which artificial teeth are made except that it is more fusible, its fusing point being 2300° F.

Platinum and iridio-platinum are used as the bases, and we find the tissues underlying them to maintain a condition more closely approximating the normal than under the vegetable bases.

The objections formerly urged against this variety of artificial denture, viz.: its great weight and the dangers and difficulties in the baking of the porcelain, have been removed to a large extent by improved methods of construction.

The first objection as to weight may be overcome in a large measure by using the lighter gauges for the platinum base. The writer has for a number of years used Nos. 32 to 36 plate (B. & S. gauge) for upper dentures with most satisfactory results.

The use of modern electric furnaces effectually discounts any objections on the score of baking *per se,* for these appliances are thoroughly satisfactory in convenience of operation and efficiency. The consideration of the warping of the plate, the shrinking, flaking, under- and over-fusing of the porcelain—accidents possible in the process of baking and urged by some as objections to the method, will be discussed at the appropriate place in this chapter.

As a minor objection may be mentioned the liability of fracture of the denture. Proper admonition to the patient as to the care of the denture should always be given, and by the exercise of due caution in cleansing the piece, any annoyance on this score may be avoided. Fracture in the mouth is of rare occurrence.

The tissues of the mouth react more kindly to the presence of a platinum base denture than they do to any of the vegetable bases. All the materials of which the denture is composed being good conductors, the thermal variations are readily communicated to all the underlying parts. From a hygienic standpoint, the platino-porcelain denture stands alone. There are no interstices to catch food débris, and as the denture is absolutely uninfluenced by the secretions of the mouth, or the products of bacterial action, it may be made as clean and fresh as new by ordinary cleansing methods which may be instituted by the patient. One of the chief points of excellence in favor of the continuous-gum method is the facility and accuracy with which the natural organs are imitated. Any loss of gum or palatal contour may be so faithfully reproduced in form and color as to defy detection.

Continuous-gum dentures are applicable with most satisfactory results in full cases, upper and lower, but it is quite possible to employ them with good effect in many cases requiring partial dentures.

IMPRESSIONS AND CASTS.

The first requisite for success in constructing continuous-gum dentures is a good impression, and for this purpose plaster of Paris is the material *par excellence.* The manner of taking the impression and its subsequent treatment are described in detail in another section of this work. The cast is obtained and dies and counter-dies made as for other varieties of metal dentures. The indications which govern the use of vacuum-chambers are the same as for other metal plates. If in the judgment of the operator a vacuum-chamber is indicated, it may be carved in the impression, thus forming an integral part of the cast, or it may be placed upon the cast after the latter has been removed

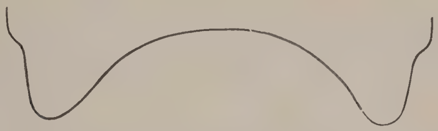
Fig. 487.—Showing form of arch where chamber may not be necessary.

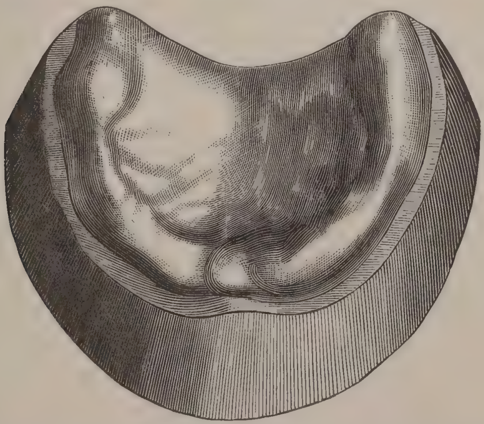
Fig. 488.—Cast of the upper jaw with ledge for turning the rim.

from the impression in any of the ways described in Chapter IV. In cases presenting well-defined alveolar ridges and moderately deep vaults the vacuum-chamber is unnecessary (Fig. 487). The firmness of the adhesion of the denture to the underlying tissues depends upon the accuracy of its adaptation to them. If this is perfect it will adhere with sufficient tenacity, but if the denture is poorly adapted or warped in any degree, the stability of its retention is thereby lessened proportionately. If it is intended to swage a rim to the plate, especial care must be exercised in marking the outline of the latter on the cast (Fig. 488). It should follow such a line as will prevent any possibility of its impingement upon the muscles of the lips and cheeks or other movable tissues. If after the piece is finished such impingement does exist, the beauty and finish of the denture would be seriously marred by trimming. A layer of wax slightly thicker than the proposed rim is adapted to the cast, following accurately the plate outline. It should form with the wall of the cast an angle, the degree of which should not be so acute as to interfere with accurate molding. The wax is then trimmed away to blend gradually with the sides of the cast. The cast thus prepared is now to have the necessary varnish applied and the die is obtained in the usual way.

Results obtained with dies made of nickel Babbitt's metal, or Babbitt's metal of Haskell's formula, will be found satisfactory in this work. The latter alloy contracts less than zinc, and plates made over dies composed of it fit the plaster cast as they do the die.

FORMING THE FULL UPPER DENTURE.

The pattern of the plate in heavy tin-foil is reproduced in pure platinum No. 32 to No. 36 gauge for upper dentures, the thickness of the platinum depending upon the form and size of the plate. The writer has used all gauges and finds plate of these numbers, properly reinforced, to meet the individual requirements, not only sufficiently rigid for all purposes, but contributing much to the lightness of the completed denture.

The face of the die is covered with a thin piece of wet muslin, and the platinum, after being well annealed by placing the platinum in the electric furnace, bringing it to a white heat and allowing it to cool slowly, is adapted as closely as possible to the palatal vault by pressure applied with the thumbs, and by the use of the horn mallet. Great care must be observed while annealing the platinum that no particles of zinc or lead are attached to it, for they would become alloyed with it, thus producing a hole in subsequent heatings, or causing the plate to crack or break in swaging, or possibly subsequently discoloring the porcelain paste. Using muslin over the face of the die, and pickling the piece each time before it is annealed to remove any possible trace of base metal will effectually prevent this. The process of swaging is continued, reannealing the platinum whenever its returning obduracy necessitates, until a fairly close approximation to the vault is obtained. A partial counter-die made of good modeling composition may now be used. The composition is softened and molded to the vault of the plate, completely filling the latter. It is then hardened by dipping into cold water. The composition is now placed in position on the plate which is in place on the die, and the whole is clamped securely to the bench with an ordinary bench clamp, one arm of the clamp engaging the under surface of the bench, the upper arm engaging the composition. In this manner the plate is held securely in position on the die while its alveolar borders are adapted with the swaging mallet.

The soft platinum exhibits a tendency to wrinkle and tear under manipulation, so that all undue haste and force are to be avoided. If, however, the metal should be torn, small breaks in its continuity may be repaired by soldering a piece of thin platinum, No. 36 gauge, over the hole with platinum solder.

When the adaptation to the die is as accurate as can be obtained by pressure and the mallet, the plate is trimmed approximately to the line marked on the cast. It is now ready for the counter-die, and extreme care should be observed to prevent contact of the platinum with the base metal of the counter-die, particularly if the latter be made of lead or an alloy containing that metal. As is well known, lead and platinum combine with remarkable ease, and should small particles of lead become attached to the platinum when the latter is heated, the base metal forms an alloy with that part of the platinum with which it is in contact. This alloy is very fusible, and if the plate is not at once perforated, the part so contaminated will always be liable to this accident upon subsequent heatings. To avoid any such contingency it is well to interpose between the surfaces of the counter-die and plate, wet muslin or thin rubber dam. This will also assist in disengaging the plate from counter-die if, as frequently happens, it becomes wedged therein from the force of the swaging. Should the platinum become contaminated with the base metals, it must be pickled in hot nitric acid before further annealing.

The plate is at first lightly swaged between die and counter-die, then removed and examined carefully for wrinkling or breaks. Should wrinkles develop, they should be corrected with pliers and the horn mallet. The swaging should alternate with pickling and annealing until the adaptation is perfect. The plate is then closely trimmed to the plate outline, leaving an excess sufficient for the rim if this is to be turned, and it is ready to be tried in the mouth. The rim is to be completely turned after the first coat of body has been baked.

The operator may prefer to solder a wire along the alveolar border of the plate instead of turning the rim, in which event the plate is to be trimmed to its true dimensions which are determined by trial in the mouth. The wire rim permits a trimming of the plate margins after the body has been applied and even after the denture has been worn.

The vacuum-chamber in a continuous-gum denture is preferably formed in the plate itself, although it may be cut and soldered, using for the chamber cap a piece of plate of the same thickness and soldering it in with 25 per cent platinum solder. This is the solder employed to best advantage in continuous-gum work. The relative position of the pieces united by it will not change in the intense heat of the furnace. Pure gold may be used if the pieces are in absolute contact and a minimum amount of solder used, but an excess of gold should be avoided, as it is thoroughly melted and widely diffused by the high temperature at which porcelain fuses. Solders containing base metals should never be used.

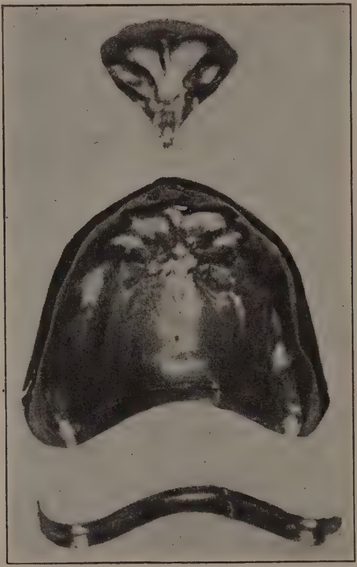

Fig. 489.—Reinforcing pieces for full upper denture.

Strengthening Pieces.—The object of these is to add strength to the parts of the denture which are liable to undergo alteration in form, either when it is subjected to the great heat of the furnace, or under the stress of mastication. Those places in which experience has demonstrated the necessity of additional strength are the posterior border of the denture, usually referred to as the heel, and that portion of the denture extending posteriorly for a small distance from the alveolar border along the median line.

The form these strengthening pieces should take is governed by the judgment of the operator. The method of forming and adjusting them employed by the writer is as follows: Patterns of heavy tin-foil are prepared; the pattern for the anterior piece is cut roughly to the form of a triangle, the base slightly overlapping the ridge anteriorly; the apex extending back toward the vault of the plate and lying on the median line, the size to be governed by the size of the denture. (Fig. 489). This pattern is to be reproduced in iridio-platinum plate, No. 24 to No. 26 gauge, according to the case. The piece is well annealed, adapted to the die with the mallet and then swaged between the die and counter-die. It is now placed in position on the plate and both are swaged together.

The posterior pattern is cut in the form of a strip $\frac{3}{16}$ inch wide, extending across the entire posterior border of the plate. This pattern is also reproduced in iridio-platinum No. 24 or No. 26 gauge. It should be observed that the object of this piece is two-fold: (1) To give additional strength to the heel of the denture; (2) to engage the porcelain and give finish to this part of the denture. In order to serve best this double purpose the strip should be so formed that when finally adjusted its anterior edge is distinctly raised, while the posterior two-thirds of the body of the strip lie in close apposition to the plate. To accomplish this result a strip of brass is swaged to conform to the portion of plate immediately in front of and covered by the anterior border of the iridio-platinum piece when the latter is in position. The posterior border of the brass strip should be filed to a feather edge. The strengthening piece, having been adjusted to the die and swaged in the usual manner, is now placed in position on the plate with the brass strip properly interposed, and the pieces are swaged together between the die and counter-die. The brass having accomplished its purpose is then laid aside.

The plate and pieces are given an acid bath, washed and cleansed thoroughly, and are ready for soldering. The anterior piece is clamped to the plate and around its border are placed small squares of platinum solder; the case is heated to bright redness with the ordinary blowpipe, the fine flame of the oxyhydrogen blowpipe (Fig. 490) is then directed against the plate and solder, causing the latter to flow and unite the pieces. The posterior strip is attached much in the same manner, except that the solder should be placed only along the posterior border. This latter operation will be greatly facilitated if the operator defers the final trimming of this portion of the plate until the piece has been soldered, the extended heel of the untrimmed plate serving as a support upon which to place the solder. By this means the risk of flowing solder upon the palatal portion of the plate is prevented. In a plate thus reinforced we have combined to the best advantage the qualities of strength and lightness, and have provided for the successful application of the porcelain body.

The adaptation of the plate may now be tested on the cast. If a Babbitt metal die has been used, it should fit this perfectly, and pressure applied at any point should cause no movement of the plate on the cast. Rocking is frequently due to the fact that some prominence on the die has been bruised in swaging. For this reason it is always desirable to have a finishing die upon which the last swaging is done, for by this means inaccuracy in fit due to an imperfect die may be avoided. For a more perfect adaptation, the plate should receive its final swaging directly on the plaster cast with the shot-swaging device.

It is then tried in the mouth and its adhesion tested; also the relation which its borders bear to the muscles and soft parts is carefully noted. If the adhesion is defective it is usually due either to impingement upon the muscles or soft palate, or to variations in the resistance offered by the underlying parts. If due to the former, the plate is trimmed at the proper places. If due to the latter, the part of the die corresponding to the soft areas is scraped away and the plate reswaged. It should be noted that any subsequent swaging of the plate after the reinforcement at the heel is attached should be done for obvious reasons with the brass strip adjusted under the free edge. If the stability of the plate is not corrected by these means, a new impression is taken, the hard and soft areas of the mouth carefully outlined on the cast, and these properly treated by scraping or by additions to the face of the cast, new dies and counter-dies obtained and the process of swaging repeated.

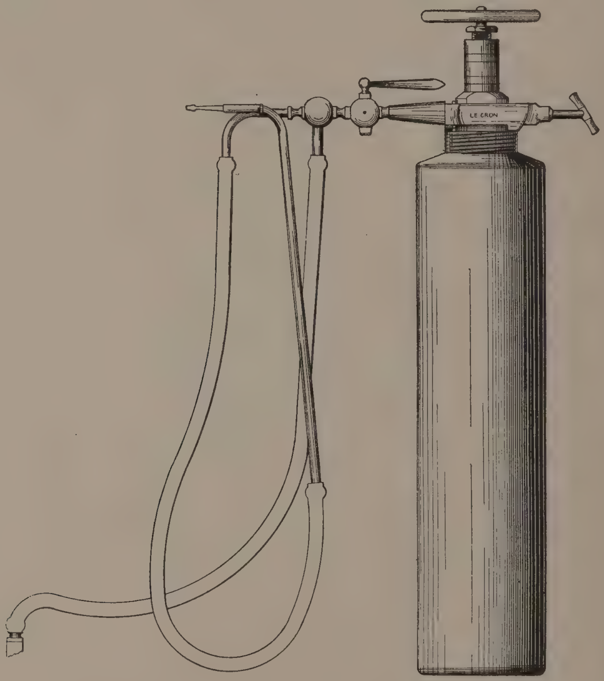

Fig. 490.—Le Cron's blowpipe.

ARTICULATION.

If, on trial in the mouth, the fit and adhesion of the plate are satisfactory, we are now ready for the operation of "taking the bite." Next to a good impression no step is more important in securing happy results in continuous-gum work than the securing of a good "bite," since this is the guide in the articulation of the teeth.

The plate is warmed, a rim of wax is placed around the alveolar ridge and attached to the plate with a hot spatula. The plate is then placed in the mouth and the wax modeled to restore the contours of the cheeks and lips, and the median line of the face marked upon it. The lower edge of the wax governs the length of the teeth. The surface of the wax is now slightly warmed and the patient is instructed to close the jaws in a natural manner, leaving the imprint of the lower teeth in the wax. The case is then attached to the articulator for the arrangement of the teeth. Any of the bite-taking methods described in Chapter V may be substituted.

In full cases the selection of the teeth is governed by the age, temperament and physiognomy of the patient. Where there are natural teeth remaining, these will serve as a guide as to their shape, size and color. Teeth especially designed for continuous-gum work are generally used. They are made with single long platinum pins and long porcelain projections representing the roots. These porcelain extensions are for the purpose of insuring contact of the teeth with the platinum base and they also assist in the formation of the buccal and labial contours of the denture. The fact that the porcelain root is not fused in the baking of the body reduces the contraction, and maintains the contours in these regions (Fig. 491). When the requirements of the case call for very short teeth those employed in vulcanite or celluloid work may be used.

Any artistic skill which the operator may possess has wide latitude for its display in the arrangement of the teeth. The varying facial expressions of the patient are studied closely and the endeavor is made to fix in the mind the natural expression both in repose and when the face is animated, as in the acts of talking and laughing. Not only must an accurate knowledge of all the elements entering into and constituting what is known as the natural expression be borne in mind, but what is as equally important from a less esthetic standpoint, a thorough knowledge of the mechanical principles involved in the retention of the denture. A just consideration of these observations leads to the further statement that in the construction of an artificial denture the process is often attended by a series of compromises by which the various esthetic features are reconciled to the practical requirements. Therefore, a comprehensive knowledge of all these factors will best place one in a position to so adjust the conflicting interests that the finished product will not suffer.

The central incisors are usually arranged first. Each tooth is ground

Battersea Public Library.

to rest directly on the plate, and the pin should come in perfect contact with the wire on the top of the alveolar ridge, presently to be described, or with the plate, in order to hold the tooth in position during the process of fusing the porcelain. Between each tooth and the platinum base there should always be two points of contact, viz.: the platinum pin and the porcelain root; the teeth will then be less liable to change their position by the shrinkage of the porcelain. If the length of the roots is not sufficient to enable them to touch the plate it will be necessary to support them in position by interposing little pieces of broken porcelain teeth.

Slight irregularities of alignment commonly found in the natural teeth are easily reproduced and materially aid in giving a natural appearance to the case.

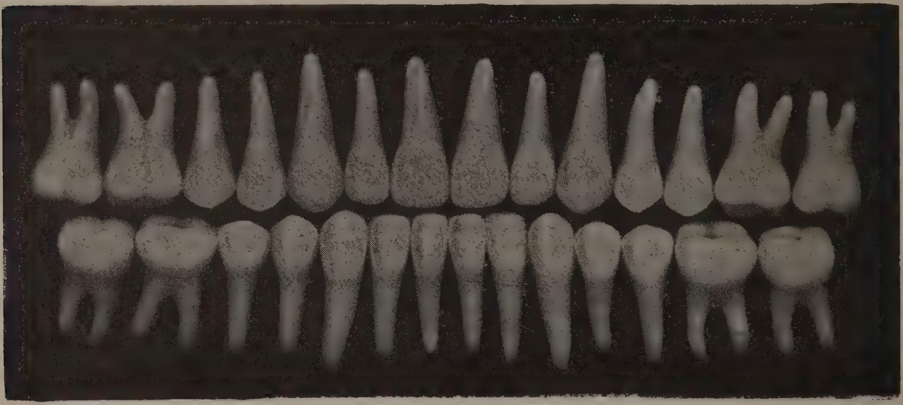

Fig. 491.—Set of continuous-gum teeth.

There are often conditions of the remaining natural teeth resulting from decay and organic discoloration, which make it impossible to find in the stock of the manufacturer a desirable match for a partial denture. Such needs of the operator can only be met by selecting a porcelain tooth, the body of which is the same general color as the natural teeth to be matched and treating it with mineral colors in imitation of the natural organs. (Fig. 492.)

After the arrangement is completed in conformity with the ideas of the operator the teeth are attached to the plate with adhesive wax. Wax is also loosely molded over the buccal and labial walls of the plate to approximate the natural contours.

The piece is now transferred to the mouth, the articulation noted and any slight corrections or alterations made. The amount of wax necessary to restore the contours is also to be noted; this serves as a guide in the application of the body.

The next step is the adjustment of the iridio-platinum wire around the crest of the ridge, which serves for the attachment of the pins and also gives additional strength to the plate. The writer advocates the use of No. 16 iridio-platinum round wire instead of the platinum strips which are sometimes employed. The porcelain adapts itself more uniformly to the wire and fuses with less tendency to crack.

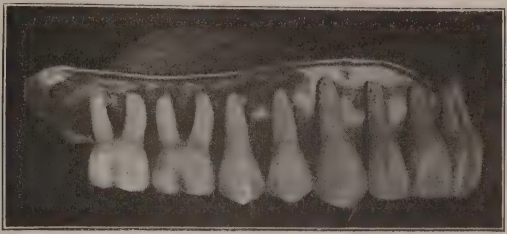

FIG. 492.—Base-plate with teeth arranged upon it.

In determining the proper position for the wire, the denture is placed on the cast, and a wall of soft modeling composition is adapted to cover the anterior and lateral walls of the cast and all exposed portions of the teeth, and extending from the last molar on one side to the same tooth on the other. The composition is hardened and the wax removed, thus freeing the pins, which are bent slightly upward. The wire is adjusted under the pins and waxed to the plate. The teeth should then be removed *en masse* with the composition. The wire is now held in position on the plate with clamps like that shown in Fig. 493 and soldered. The modeling composition wall containing the teeth is then returned to the plate in position on the cast, the pins bent down in contact with the wire and securely attached with adhesive wax. The composition wall may then be softened by dry heat and removed, taking care that the wax about the pins is not melted and that the relation of the teeth to the plate is undisturbed. A plaster wall may be used instead of the one described. After the teeth are attached to the plate the case is ready for the investment.

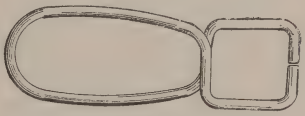

FIG. 493.—Clamp for holding reinforcing pieces on plate during soldering.

INVESTING.

The investment best adapted for continuous-gum work is composed of fine asbestos, $\frac{1}{6}$; coarse calcined silex, $\frac{1}{2}$; plaster of Paris, $\frac{1}{3}$.

The investment best adapted for continuous-gum work is one sufficiently plastic to flow freely between and around the teeth. All surfaces of the teeth to be embraced in the investment should receive a coating of thick shellac varnish. This is to prevent the fusing of the investment with the porcelain teeth during the soldering, an accident which is likely to occur at the high temperature required to fuse platinum solder. The shellac burns out when the plate is heated up and leaves a small space about the teeth.

To make the investment small, uniform in thickness and compact, a matrix into which it may be cast is formed by placing the plate with teeth attached upon a flat surface like the work bench, the occlusal surface of the teeth being uppermost. Then a strip of base-plate wax is bent into the form of a ring, which shall surround the plate, follow its general form and be $\frac{1}{4}$ inch larger in each direction. The ring should be deep enough to extend $\frac{1}{4}$ inch above the cutting edges of the teeth. The ring thus prepared is now set on a glass slab and attached thereto by passing a hot spatula around its edge. This forms a cup-like matrix into which the investment is cast.

The investment is now mixed as described above and first applied thoroughly to the palatal surface of the plate, allowing it to flow between and over all exposed portions of the teeth. The matrix is filled three-quarters full and the plate inserted, palatal surface downward, and pressed down until it is within $\frac{1}{16}$ inch of the glass slab. The excess of material is forced up and around the teeth, covering the incisal and occlusal surfaces to a depth of $\frac{1}{16}$ inch and filling in the lingual side of the vault.

The investment should be fully set before it is removed from the matrix. After it is thoroughly dry and hard the wax may be detached from the teeth by subjecting the case to dry heat until the platinum becomes warm, when the wax may be readily removed. Hot water should never be used, as it destroys the integrity of the investment material, thereby frequently causing it to fracture under the subsequent application of heat.

All surfaces from which the wax has been removed are to be thoroughly cleansed with chloroform.

SOLDERING.

The pins of the teeth are bent so they are in perfect contact with the wire and plate. Small squares of platinum solder are placed at these points of contact and retained in position by a coating of borax. The borax is not intended as a flux, as the noble metals do not oxidize and a flux is not required, but it keeps the solder in place.

There are numerous methods of heating up the case preparatory to soldering. Quite a satisfactory one which the author has frequently used is to set the invested case in a bed of broken pieces of burnt fire-clay over a Bunsen burner. This fire-clay is prepared by incorporating with it starch or sawdust, breaking it up into pieces of suitable size, and firing them. The combustible constituents burn out, leaving the pieces porous. When thus prepared the mass may be heated thoroughly in a very short time, and it also possesses the advantage of cooling slowly.

With the aid of an ordinary gas blowpipe the case is gradually heated to a dull orange color (2000° F.). The flame from the oxy-hydrogen blowpipe is then directed against the parts to be soldered until the solder flows.

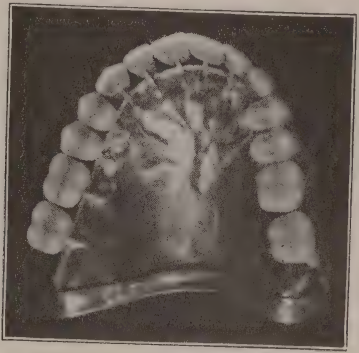

Fig. 494.—Full upper base-plate, showing wire soldered upon top of ridge and teeth soldered on.

Each pin should be carefully examined to see that it is securely attached to the wire or plate. When we are assured of this, the case is allowed to cool gradually; this is conveniently done by placing a cover over the receptacle containing it. When quite cool the investment is removed and the denture boiled in dilute sulphuric acid, and washed in water until every trace of foreign substance is removed. It is now ready for its final trial in the mouth (Fig. 494). The adhesion and articulation are noted; any slight corrections in the arrangement of the teeth may be made at this time. After it is removed from the mouth, the plate is placed on the cast, and all surfaces of the platinum to which the porcelain is to be applied are roughened by gentle scratching with a sharp excavator.

The plate is made scrupulously clean by washing with chloroform or alcohol and is ready for the first application of body. The utmost degree of cleanliness must be observed in all the subsequent manipulations. Any dust or particles of foreign matter coming in contact with the porcelain body will seriously affect the beauty and integrity of the finished product.

The Porcelain Body and its Manipulation.—The degree of success to be achieved now depends upon the skill and judgment manifested in dealing with the purely ceramic features of the case. The manipulation of the porcelain paste is considered in three stages; upon the application and carving of the first coat of body largely depends the final artistic effect. For the application of the paste and its esthetic carving, the set of instruments illustrated in Fig. 495 will be found very useful.

The porcelain body is prepared on a clean glass slab. It is mixed into a paste with distilled water to the consistence of thick cream. It is applied first to the lingual concavity of the palatal portion of the plate, between and about the roots of the teeth, jarring the plate at intervals to insure compactness of the body. The moisture rising to the surface is to be absorbed with clean blotting paper cut into strips for the purpose. If slight pressure is exerted with the blotting paper upon the surface of the body it will be condensed and less shrinkage will ensue. When this portion is covered uniformly to the proper thickness, which is that of No. 24 gauge, the rugæ and other features found in the roof of the mouth are modeled in the body.

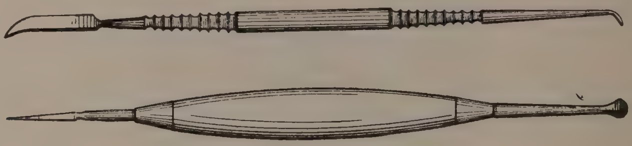

Fig. 495.—Instruments for carving the porcelain paste.

On the labial and buccal surfaces the paste is applied in the same manner. The contours of these regions are roughly brought out in the manipulation of the body, but no attempt is made at accurate carving. No instructions may be given as to the correct carving of these features. This must be learned by a close observation of Nature and by abundant practice. The crowns of the teeth are kept well defined and thoroughly freed of any adhering porcelain paste.

To prevent the teeth from moving and the plate from warping by the contraction of the body in fusing, it is necessary to take into account the shrinkage which will take place in this process. Shrinkage occurs in three stages of the baking: (1) As the water dries out of the mass and the solid particles more closely approximate each other; (2) when the particles begin to combine by fusing; (3) as the mass becomes vitrified. The principal cause of shrinkage may be said to be the agglomeration of the particles which were previously mechanically separated by the water expelled in the drying out process. This is followed by the fusing of the component parts of the body, and further contraction is due to this.

When the mass of porcelain is attached to a platinum base it will either separate at its weakest place or the plate will warp; consequently, to prevent either of the above contingencies, shrinkage must be provided for by dividing the porcelain body into small masses so disposed that their contraction will neither disarrange the teeth nor warp the plate. A fine ribbon saw is passed between each tooth dividing the body entirely to the base. The cuts are continued on the lingual aspect of the plate.

It is noticed in firing the low-fusing bodies, that the contraction is largely vertical, because of their tendency to assume a globular form when fused. The high-fusing bodies stand as carved, contracting symmetrically to the mass when uninfluenced by any extraneous factors.

The case, now ready for the first baking, is placed in the furnace, resting upon the palatal portion of the original investment, or, better, upon a support of iridio-platinum wire bent into a "V" shape with upturned ends.

FURNACES.

The great length of time necessary to heat up the old style porcelain furnaces was a strong objection to this kind of work; consequently, to meet the requirements of the present day a furnace intended for continuous-gum work must be available, which can be used with the expenditure of less time than formerly. It must be so constructed that there is no possibility of a contamination of the porcelain denture by the products of combustion.

Wherever it is possible to use it the operator will make no mistake in selecting one of the approved electric furnaces which the manufacturers are now offering. Among the many advantages possessed by this type of instrument, may be mentioned the facility with which it may be handled and the small space which it occupies. With it there is no danger of "gassing" the work. Its cleanliness, the complete absence of odor and noise, and its beauty of finish as now constructed, recommend it highly in the furnishing of a well-equipped laboratory. If lack of space in the laboratory prevents it may even find a place in the operating room. The chief advantages, however, of the electric furnace are the ease and accuracy with which the requisite heat may be applied, controlled and maintained. The construction of the furnace is such that the case may be heated uniformly and evenly throughout, the degree of heat is under perfect control and it is claimed that porcelain fused by this method possesses unusual clearness and density.

In those localities where the electric current is not available, the operator may find his demands satisfactorily met by the use of some form of the gasoline furnace. Very excellent results may be obtained by this method of fusing porcelain and the country practitioner need not hesitate to undertake the work with a furnace of this character.

A thorough acquaintance with the management of the furnace is indispensable, as probably the most prolific source of failure in continuous-gum work is lack of knowledge in this regard. Each individual furnace should be accurately tested by the operator and its working capabilities carefully observed. The temperatures at which the different porcelain bodies and enamels fuse should be noted; also the effects produced upon them by variations above and below their fusing-points. Where a case necessitates several bakings with the same body, the temperature scale must be marked for the proper limit of fusing for each baking. Because of the fact that the formulæ of porcelain bodies and enamels on the market vary in composition, fusibility and other physical properties, no general rule, can be given for the regulation of temperatures. If the composition of all the bodies were the same and their working qualities were constant, the fact would still remain, that each furnace is a law unto itself. This applies not only to furnaces of different manufacturers but to those of the same make.

Until recently, no positive test for the correct fusing-point was known. Fairly good results may be obtained by placing a pellet of pure gold in the muffle of the furnace near the denture, and after this melts at 2016° F., by maintaining the heat for a definite length of time.

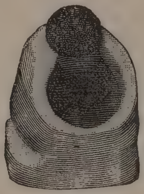

FIG. 496.—Le Cron's pyrometer.

More accurate results are secured by using the pyrometer (Fig. 496), designed by the author. This device is exceedingly simple in construction. A small cube of soapstone is excavated to resemble an hour-glass; into the upper expanded cavity is placed a small spherical mass of an alloy composed of platinum and gold. The relative proportion of the two metals governs the fusing-point of the alloy; so by varying the proportions, the temperature may be graduated to any extent within the limits desired. The proper temperature of fusing for a given body is matched with a pellet of alloy. The pyrometer is set in the muffle, and when the temperature at which the porcelain fuses has been reached the little metal ball melts and runs down into the lower chamber.

Below are tabulated the results of experiments conducted by the writer with the pyrometer to determine the fusing-points of some of the more prominent porcelain bodies found on the market.

Allen's body	2340° F.
Close's body	2290° F.
White's inlay	2300° F.
Whiteley's	2240° F.
Ash high-fusing	1900° F.
Gum enamel (Close and Whiteley's combined)	2140° F.

In the further prosecution of these experiments the writer is led to the conclusion that the maximum strength obtainable in porcelain is developed by the proper regulation of the heat. If underbaked it will be brittle, flaked and incapable of withstanding the stress of mastication; while overbaking causes porosity and diminution in power to resist crushing stress.

First Baking.—The piece is placed in the muffle of the electric furnace. It is desirable to heat it up slowly at first, so that it may dry out and so that it will not flake by the sudden formation of steam in the body from the water used in mixing it. The heat is turned on and gradually raised, placing the lever of the rheostat on the first button. It is allowed to remain on the first button for five minutes and then turned to the next button; on this and each of the following buttons it remains two or three minutes, until the last one is reached, where it rests.

During this time the case is watched carefully to determine the proper degree of baking. Less heat is required for this than for subsequent firings. The baking is carried to what is known as the granular or biscuit stage, at which point all shrinkage has taken place. The surface is not quite glazed, but presents rather a frosty appearance.

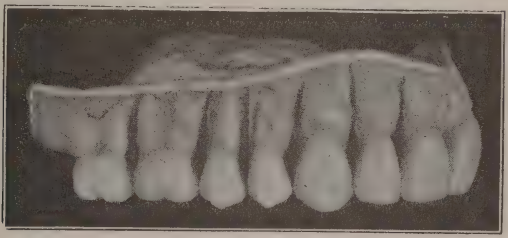

Fig. 497.—Labial and buccal view of denture after first baking.

When the process of fusion has reached the desired stage as indicated by the pyrometer, the rheostat is thrown back and the current turned off and the case allowed to remain in the muffle until cooled. It is then placed upon the die and the rim turned with flat-nose pliers and riveting hammer, holding the plate firmly in place. The rim is turned to the desired angle, which depends upon the thickness of the gum, the purpose being to make the external surface of the rim and that of the porcelain of the gum continuous in the finished piece. The case then presents the appearance illustrated in Figs. 497 and 498.

The case is now ready for the second application of porcelain. The paste is mixed and applied as in the first instance, filling in the fissures and restoring more fully the contours. When this is done all traces of the paste are removed from the surfaces of the crowns of the teeth and platinum base which are not to be covered with porcelain. This may be done with a camel's-hair brush, the bristles of which have been cut off to make them stiff. The plate is now placed in the muffle as before and subjected to the second firing. The temperature for this operation is carried a few degrees higher than in the first baking in order to produce more complete fusion of the porcelain body. The porcelain body is brought just to the verge of a glaze: its surface should show a sparkling granulated appearance. Carrying the heat beyond the stage necessary to produce this effect lessens the strength of the porcelain, and makes it impossible to obtain the translucent appearance of the gum when the gum enamel is applied. (Fig. 499.)

After being allowed to cool as before, the denture is tried in the mouth to note if any alterations in its form have taken place. The extent of the buccal and labial contours of the denture is also noted. If too full at any place, the contour may be reduced by grinding; if lacking at others, more porcelain may be added and the piece rebaked.

Applying the Gum Enamel.—The gum enamel is now prepared by mixing it with distilled water and it is applied in the same manner as the body. The denture should be wet to facilitate the placing of the enamel. This layer should be thin and so applied as to preserve the distinctness of the gum outlines. By varying its thickness those differences in shade observed in the natural gum over the roots of the teeth may be secured, as the yellowish-white of the body is allowed to show through more or less clearly at these points. The outlines of the necks of the teeth and rugæ are clearly defined. All superfluous portions of the paste are carefully removed, using small camel's-hair brushes and instruments designed for the purpose. The piece is again subjected to the heat of the furnace.

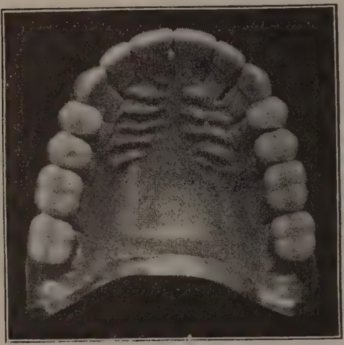

Fig. 498.—Lingual view of full upper denture after first baking.

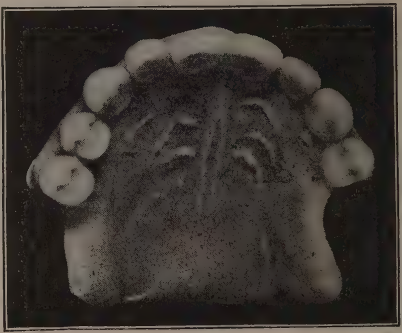

Fig. 499.—Lingual view of partial upper denture after second baking.

The exact degree of heat necessary to develop the full beauty and strength of the case can only be determined by experience. When the heat approaches the fusing-point it is well to turn off the current and make an inspection. When finished it should present a smooth, glossy appearance. If the heat is carried a few degrees too far, the color begins to fade and its brilliancy is lost. Frequently little pieces become detached and minute cracks present themselves. These defects may be remedied by applying more enamel and repeating the baking. The natural gum effect cannot always be secured with the enamels as found on the market. A combination of several of them often produces the shades desired. The writer obtained desirable results in many cases by combining the Close and Whiteley gum enamels and adding a small quantity of White's inlay body. Doubtless other combinations produce equally good results. With the exercise of patience the operator can obtain almost any shade desired.

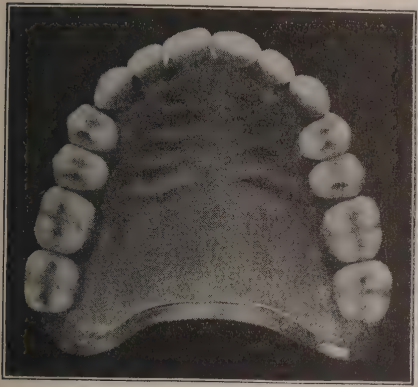

FIG. 500.—Lingual view of upper denture after baking of gum enamel.

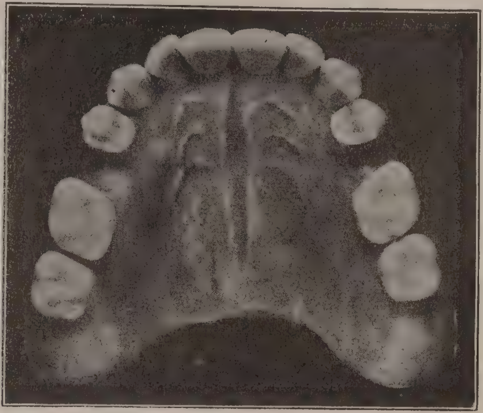

FIG. 501.—Lingual view of upper denture after baking of gum enamel, showing omission of one tooth and irregular alignment.

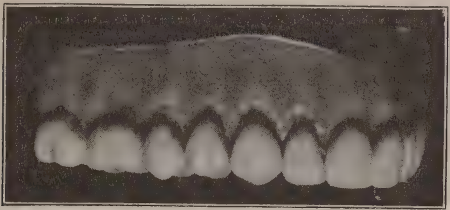

FIG. 502.—Buccal and labial view of denture after baking of gum enamel, showing imitation of recession of gums, and staining of necks of the teeth.

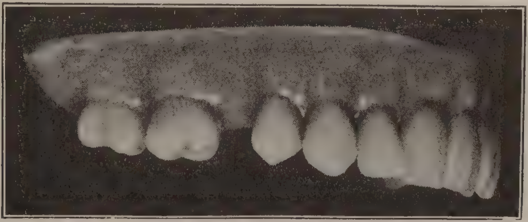

FIG. 503.—Buccal and labial view of denture after baking of gum enamel, showing omission of one tooth and irregular alignment.

The finishing process consists simply in smoothing and polishing the metallic surfaces and washing the denture. The metal portions must have any marks due to files or pliers removed, and the polishing is done on the lathe in the same manner as for any other metal-base denture.

Mineral Paints.—As previously mentioned, there are often conditions of the natural organs associated with decay and discoloration from other causes, which may be imitated in the porcelain teeth by the judicious application of mineral paints. The method of applying and fusing these paints may be readily learned, and a little study in the mixing and blending of colors will enable the operator to produce very correct imitations of these defects in natural teeth. (See Chapter VIII.)

These stains are applied on or around the cervical margins, the cutting edges, occlusal surfaces or any other portion of the tooth, imitating those discolorations seen in the recession of the gums, mechanical abrasion, devitalized or decayed teeth. The effect is still more pleasing if previous to staining, the cusps or edges of the teeth are ground off to imitate the wear incident to age. Pitting or other defects of structure which obtained in the natural teeth may be well imitated by this procedure. There is practically no limit to the possibilities offered by this process in the hands of a skilled operator.

FULL LOWER DENTURE.

The general considerations set forth under the discussion of the full upper continuous-gum plate, apply equally to other forms of plate embraced under this title. Hence in discussing the full lower or the partial upper and lower plates, it will only be necessary to mention those departures from the general line of procedure which are made necessary by the requirements of the particular case.

The first step in the construction of the full lower case is that of forming the pattern. Heavy tin-foil is accurately adapted to the die and trimmed slightly larger than the plate outline to provide for any possible displacement of the plate in swaging. Great care must be observed in preparing patterns for lower and partial cases to prevent change of form when the tin-foil is flattened out, for should this occur a plate cut to such an inaccurate pattern would be useless. Because of the inherent weakness in the shape of a lower plate, heavier gauges are used than for upper cases, and, furthermore, these are especially reinforced. The quality of lightness is not so much a desideratum as in the upper denture, and strength may be gained in this manner without affecting the success of the denture. The pattern is reproduced in No. 28- to No. 30-gauge platinum plate, and this is reinforced around the anterior lingual curve with a piece of iridio-platinum plate No. 26 gauge. The supplementary piece should extend from the rim on the lingual surface, up and well over the ridge as in Fig. 504.

The rim may be turned as for an upper plate if it is desired, but a platinum wire No. 18 gauge, soldered along the borders of the plate, is to be preferred. This will not only provide additional strength, but it permits the trimming of the plate edges, which is so often necessary with lower dentures. An iridio-platinum wire No. 14 to No. 16 gauge is to be adjusted on the ridge of the plate under the pins of the teeth, as in the upper plate. This serves for the attachment of the pins. The subsequent procedures are the same as those outlined for a full upper case.

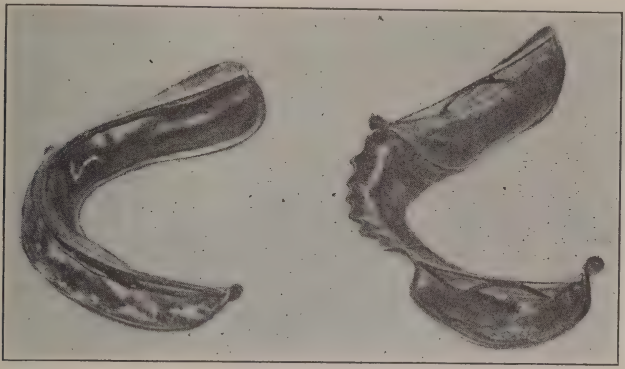

Fig. 504.—Reinforcement of full and partial lower plates.

PARTIAL DENTURES.

Continuous-gum is employed to best advantage for partial restorations in those cases in which the teeth to be replaced are in an unbroken column. More patience and skill are required in the construction of partial dentures than in either a full upper or lower. Each individual case presents features peculiar to itself, and each will suggest the proper procedure. The chief difficulties encountered are in preventing the plate from folding or splitting during the swaging. Frequent annealing, the skilful use of the pliers and mallet, and the cutting away of the surplus metal at difficult points about the natural teeth, will aid in avoiding these dangers.

Partial Upper Dentures.—When a partial upper case presents, the first thing to be determined is the mode of retention. There are two general methods by which the stability of the denture in the mouth may be secured. In the one case, the retention is obtained by the combined forces of atmospheric pressure and adhesion, the denture covering the entire surface of the hard palate. In the other case the retention depends upon attachment to the natural teeth remaining in the arch, the denture being in the form of a horseshoe, and covering only the alveolar ridge.

To illustrate the application of the first method, we may take a form of denture carrying the posterior teeth. Obviously, retention by clasps in this case would be unsatisfactory, although it is possible even here to obtain fixation in or to the natural organs by special means. Two patterns are prepared: That for the primary plate, extending over all surfaces intended to be covered; viz.: the vault of the mouth, alveolar ridges and buccal surfaces. This is reproduced in No. 34 platinum plate. The second pattern is reproduced in No. 30 iridio-platinum plate. It conforms to the shape of the first, except that it does not extend over the ridges.

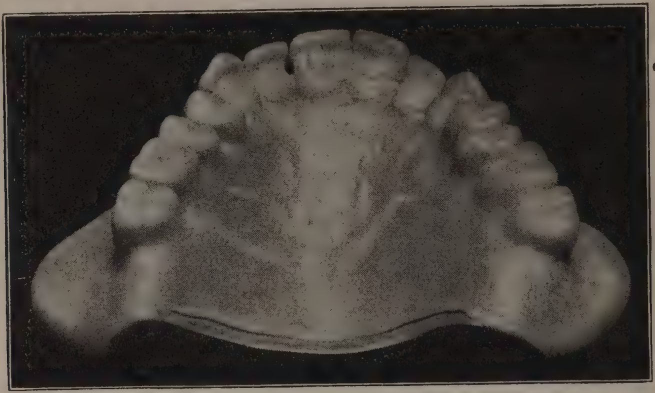

FIG. 505.—Full upper denture with lingual surface of teeth carved in porcelain; denture carrying large contours. (Wilson.)

Each lamina is swaged separately and then the two are swaged together. They are then united with platinum solder, the lateral margin of the supplementary piece being left free to form the lingual boundary of the porcelain. In this case the palatine surface is not covered with the body and no rim across the posterior border is required. The buccal rim may be formed by turning or wiring.

The patterns for the denture to be retained by the second method are adapted to the cast, and conform to the horseshoe shape, leaving the height of the vault free. The denture is preferably constructed of two laminæ, the primary of No. 30-gauge platinum, the second of No. 26- to No. 28-gauge iridio-platinum plate. They may be cut to the same pattern, though the borders of the first should be allowed to project slightly to provide support for the solder. The rim and lingual boundary of the porcelain are formed by attaching No. 18 platinum wire. This style of denture may be used to replace the anterior teeth with some of the bicuspids or molars remaining to afford attachment for the clasps. These latter are adjusted as for other swaged plates, but iridio-platinum must be used instead of the clasp metal, as the latter will not stand the high temperatures of porcelain baking.

Combination clasps of platinum and clasp metal may be made and attached in the following manner: The clasp metal is cut and adapted to conform properly to the tooth; around this is adapted thin iridio-platinum. The iridio-platinum clasp is waxed to the plate, removed, invested and soldered. It also serves as a matrix against which to build the body. The ceramic part of the denture is then finished and the gold clasp placed in position in the attached clasp, properly invested and soldered with 18-carat gold solder. The objection to this combination lies in the fact that, in case the denture requires repairing, the use of low-fusing body is necessitated.

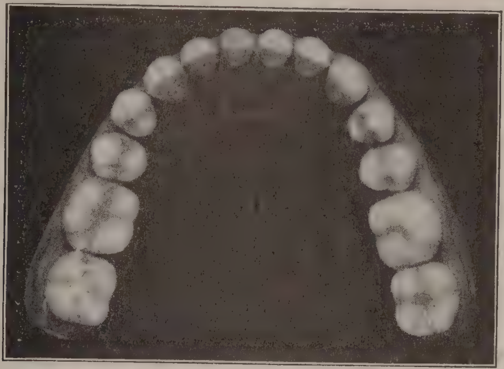

Fig. 506.—Occlusal view of completed full lower denture.

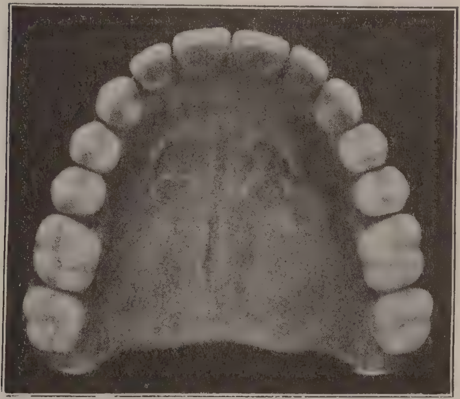

Fig. 507.—Lingual view of completed upper denture.

Partial Lower Dentures.—An ordinary form of partial restoration to which continuous-gum is applicable is that replacing the inferior bicuspids and molars. For these cases the pattern is reproduced in platinum plate, No. 30. A common source of annoyance in swaging plates for such a case is the tendency of the anterior part of the plate to displacement downward on the die. This may be prevented by allowing the sheet metal to extend over that part of the die representing the teeth and by bending it over their occlusal ends. A reinforcing piece of No. 24 iridio-platinum plate is applied to that portion of the lingual surface of the plate lying behind the natural teeth. This should extend well beyond the remaining teeth on each side and from the lower to the upper borders of the plate. The break in the continuity of the denture at the site of the natural organs makes it imperative that additional strength be provided to overcome the natural weakness at this point.

The rim is formed by soldering platinum wire No. 18 to the free margins of the plate. The other boundaries which limit the porcelain should likewise be covered with the wire. It will be observed in the illustration (Fig. 504) that the porcelain is not to be carried across the anterior lingual surface but is limited by the wire. If the curve of the alveolar ridge is marked, the plate may be braced as illustrated in Fig. 504.

TUBE TEETH WITH CONTINUOUS-GUM.

M. B. Platschick, of Paris, has a very ingenious method for the use of tube teeth in the construction of continuous-gum dentures, by means of which he obviates the necessity of primarily attaching the teeth to the plate with solder.

A platinum plate of full size is swaged after the ordinary methods; then another narrow plate is swaged to cover only the ridge or places where the pins are to be attached and the two are soldered together. The plate is then tried in the mouth and adjusted perfectly, any impingement upon movable tissues being relieved by trimming.

The rim is formed by soldering to the buccal and labial margins of the plate a platinum wire of special form obtained by means of a draw plate designed to produce it. In addition to furnishing a rim, this also reinforces the piece, and the form of the wire is such that a recess is left under its margin for the attachment of the porcelain body. It also permits the making of changes by trimming, which may be subsequently necessary despite the most careful fitting of the plate, when it is tried in the mouth.

The tube teeth are now ground and roughly adjusted to the plate. A fine adjustment would be unnecessary, as the little spaces existing between the teeth and plate are easily filled in with the porcelain body. When the teeth are adjusted and the articulation is satisfactory the teeth are secured to the plate with wax to maintain them in position. A plaster wall is formed over their external surfaces, the wax is removed and with a sharp-pointed instrument passed through each tube; the positions of the pins are marked upon the plate. The pins, of iridio-platinum wire fitting the tubes, are adjusted and soldered in place as indicated by the marks on the plate. The piece is now pickled and washed thoroughly, after which the application of the porcelain is begun. A little porcelain paste is applied around each of the pins and the teeth are then forced over them into place. More paste is then added about the necks of the teeth, and the opening on the occlusal surface is closed in like manner. The teeth are now fixed in their respective positions by baking, usually two firings being necessary for this purpose. After the teeth are thus fixed, the various applications of body and enamel are made as previously described in the usual procedure.

REPAIRING CONTINUOUS-GUM DENTURES.

An objection formerly urged against the employment of continuous-gum dentures was the difficulty of repairing them in case of fracture. The validity of this objection could not be questioned when the old methods were in vogue, but now with a more precise knowledge of the materials at our disposal, and with the valuable acquisition to our armamentarium of the electric furnace, we are enabled to undertake operations for the repair of these cases with the assurance of complete success.

When a case is presented for repair, before any other steps are taken, all foreign or extraneous material must be completely removed, not only from the free surfaces of the piece, but from the cracks and fissures as well. Any such material allowed to remain will exercise a deleterious influence upon the porcelain. The denture should first be scrubbed in water containing a little ammonia. To insure effectually the further removal of the accumulations, the plate is encased in an investment of asbestos and plaster, placed over a gas stove, and gradually heated to redness. During this process the foreign matter is carbonized. After cooling slowly, the denture is removed from the investment, washed with soap and water, and further cleansed with alcohol. It is then placed in the furnace and again heated to redness.

A detached fragment of a tooth, provided the line of fracture be distinct, may be readily replaced by the aid of liquid silex. The silex is applied to the broken surfaces, the fragment pressed to place, and the case heated in the furnace to an orange-red color. This gives a ready and quick method for this kind of repair which may be particularly useful in emergencies.

No attempt should be made to replace a broken tooth or teeth until the remaining portions are ground away. On the lingual surface the porcelain is removed until the platinum base or wire is exposed. The grinding on the buccal or labial surface should be sufficient to permit the proper replacement of the lost tooth. Teeth are selected of a mold and color to correspond with those remaining on the denture. They are ground to fit the spaces prepared for them, and at the same time are given a correct articulation. They are waxed in position and, if the length of the column of teeth to be replaced demands it, they are given a coating of shellac varnish and the piece invested to hold them in position. This wax is removed, and the pins are attached to the plate as previously described, this time, however, using pure gold as the connecting medium and the furnace as the means to fuse it. The unequal heating involved in soldering with the blowpipe would endanger the integrity of the porcelain. The case is allowed to cool, removed from the investment and cleansed. The body is applied and baked to the granular stage, after which the enameling is done as before.

It is feasible to replace one or two teeth without attaching the pins to the plate with solder, the porcelain material alone maintaining them in position. In simple repairs of this kind it is only necessary to grind away enough porcelain to permit the tooth to be set in place.

The teeth may also be retained in proper position by adapting a platinum wire No. 30 around the plate to rest upon the labial and buccal surfaces of the teeth. The ends of the wire are engaged between or around the posterior teeth remaining on the denture.

If there is a break in the continuity of the platinum base, and it is not extensive, it may be repaired by grinding away the porcelain immediately about it, adapting a thin piece of platinum plate to the break and soldering it with pure gold in the furnace. The porcelain body and enamel are then applied as already described.

Cases sometimes present which after years of service cease to be useful because of the changes in the mouth incident to resorption of the process. In such a case it will be necessary to take a new impression, obtain dies and counter-dies and reswage the plate after removing the teeth and porcelain. This may be done by subjecting the denture to a red heat under the blowpipe or in the furnace and then plunging it into cold water. The porcelain will fracture and may be easily detached. All the porcelain portions of the denture may be effectually removed by immersing the plate in hydrofluoric acid for a few hours. After reswaging, the process is the same as for constructing the original denture.

COMBINATION OF CONTINUOUS-GUM AND VULCANITE.

The ingenuity of the operator may find a fruitful field of employment in the various combinations of continuous-gum with vulcanite. The lightness, cheapness and accuracy of adaptation of vulcanized rubber may at times be joined advantageously with the esthetic qualities of porcelain.

Cases presenting extremely long bites in which the increased weight of the continuous-gum might prove objectionable may, with advantage, be restored by such a combination. A cast of the jaw is obtained, covered with a base-plate of gutta-percha, and from the model so prepared dies and counter-dies are made. A platinum plate, No. 34, is swaged to cover the alveolar ridge, making no provision for the rim. The plate is perforated at various points, and through these perforations after the porcelain body has been applied, but before baking, retaining pits are made in which to engage the vulcanite.

The plate is warmed and set over the gutta-percha; the bite taken and the articulation of the teeth secured in the usual way. It is then separated from the gutta-percha, invested, and the teeth soldered to the plate or stays. The body and enamel are applied and baked.

When this part of the denture is complete it is set over a wax base-plate, the articulation adjusted and the waxing process completed. The case is then flasked and the succeeding steps are analogous to those described in the chapter on Vulcanite Dentures.

Continuous-gum sections or full pieces may readily be constructed and mounted in the vulcanite without the platinum base. Upon a base-plate of wax, continuous-gum teeth are arranged and properly articulated. The labial and buccal contours are restored in wax; a coating of shellac is applied to the teeth and the case is removed and invested with the teeth downward in a shorseshoe-shaped bed of investment material, ½ inch thick, placed on a glass slab. The investment is built about the wax gum, covering it to a depth of ½ inch and extending well over its edge. The wax is thoroughly removed after the investment becomes hard. An iridio-platinum wire, No. 18, is adapted against the necks of the teeth under the pins, bending the latter securely around the wire to maintain the teeth in place. That part of the investment previously covered by the wax is now oiled, and the porcelain paste packed in, applying it between and in front of the roots flush with the lingual surfaces of the teeth to take the place of the wax. The case enclosed in the investment is now introduced into the muffle with small pieces of pure gold applied to the junction of each pin. The gold solder unites the pins and wire and at the same time the porcelain body is baked.

When cool, the case is removed from the investment and cleansed, given its enamel baking and then set on the cast, waxed in proper position and the denture is finished in vulcanite.

SIMPLIFIED TECHNIC FOR PORCELAIN DENTURES.

Dr. P. C. Tennis[1] describes a newer method of making a continuous-gum denture, which apparently has some advantages and which is as follows:

The methods of making porcelain dentures in the past have been not only difficult, but hazardous and detrimental to the porcelain teeth in the process of making porcelain dentures, for the reason that it was necessary to subject the teeth to the heating process from five to seven times during the soldering and the baking of the denture. The heating of the teeth so many times not only affects their shade, but causes them to become weak and brittle. With the technic herein described, it is only necessary to carry the teeth through the heating process from two to three times at the most.

The first requisite of a successful porcelain denture is a good impression, as the denture will not fit any better than the impression. After a suitable impression is procured, a cast is made. A die is then made of some good hard metal and with a suitable counter-die the platinum

[1] Am. Dent. Surg., November, 1926.

base is swedged. The case is now ready for setting up the teeth for articulation, alignment, checking the bite, etc. After determining the position of the teeth, we proceed as though we were making a transfer of an old denture, that is, the cast, the platinum base, the wax base and teeth in position are mounted on the articulator together with a plaster cast of the lower jaw. The lower half of the articulator, carrying the plaster cast of the lower jaw is removed and replaced with a lower bow. Upon this lower bow of the articulator soft plaster is built and in this plaster the incisal and occlusal surfaces of the teeth of the upper denture are embedded about $\frac{1}{16}$ inch. This is done by simply closing the upper half of the articulator, containing the teeth waxed to the platinum base, into the soft plaster.

After the plaster has hardened all the wax from the base and teeth is removed. The teeth are now placed back into the plaster matrix just made, and held there firmly by placing a small amount of sticky wax around them. This is quite necessary, as the case is now ready for the building of the porcelain on the platinum base down to the teeth, and as it will be necessary to close the articulator many times while building on and condensing the porcelain, the teeth must be held securely.

The porcelain used is S. S. White No. 37 or No. 40 M, which fuses at 2300° F. Of all the porcelains used, the writer finds this, when baked, very dense and without the porosity common to most porcelains. It can also be ground with a fine stone and water and left very smooth, thus enabling one to grind the denture without fear of leaving a roughened surface, something that is difficult with other porcelains.

A large mix of porcelain is now made ready, stirring with a spatula to the consistency of thick cream. A quantity of porcelain is placed on the platinum base, condensed by passing a roughened instrument over the edge of the base and the moisture removed with a towel. Sufficient porcelain is added to the ridge of the platinum base only, leaving the palatal portion until the second bake. After building the porcelain completely down to the teeth and when sure that it is properly condensed, it is placed in the furnace and the heat raised to the proper temperature. It is not necessary to carve V-shaped grooves in the porcelain at any place as was done in the old method. Only the base with the porcelain is placed into the furnace at this time. After baking, the base with porcelain is placed back on the articulator, and if it is found upon examination that the porcelain is in contact with all the teeth, we proceed with the next step.

The base with the porcelain is now waxed to the teeth with sticky wax so that they will be held firmly while a matrix is being made; the incisal and occlusal surfaces of the teeth are painted with a coating of shellac (heavy) and allowed to dry. Alundum cement is mixed to the consistency of putty and rolled into the shape and about the size of a large pencil. This cement is placed upon a blotter and the teeth embedded into it about $\frac{1}{16}$ inch. The entire mass is placed upon a slow fire and gradually dried until the cement has set, removing the wax as it begins to melt. As soon as the porcelain can be separated from the teeth, the cement containing the teeth is placed into the furnace and the heat raised to about 600° F. The teeth are thus cleansed and the cement hardened sufficiently so that it may be handled without danger of breaking.

It may be necessary to place the base containing the porcelain into the furnace and heat it to 600° F. to burn off any wax that may have remained. Everything is now ready for adding porcelain for the second bake. The cement matrix containing the teeth is placed upon the base containing the porcelain, and porcelain added around the teeth, building up the contour as desired and covering the palatal portion. The case is now placed into the furnace and baked, fusing this second bake just a little lower than the first. This accomplished, we can build on the pink enamel. The cement matrix may be removed after the second bake to gain access to the denture for the placing of the pink enamel to better advantage.

CHAPTER XV.

ARTIFICIAL CROWNS.

By FREDERIC A. PEESO, D.D.S.

The use of an artificial crown is indicated when the natural crown of a tooth is so injured by accident or caries that it is impossible to restore it with an inlay or a filling without rendering it unsightly, or impairing its usefulness.

There are many types of crowns manufactured by the different dental manufacturing companies, or made in the dental laboratories, any one of which may be indicated under certain conditions. Of those most commonly used in the anterior part of the mouth and purchasable at the dental depots, are the all-porcelain crowns, among the earlier of which were those of the Logan type, in which the post was an integral part of the crown, being baked into the porcelain. (Fig. 508.)

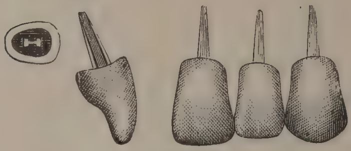
Fig. 508

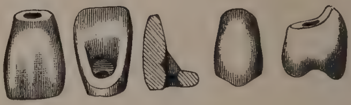
Fig. 509

Other designs were those of the Bonwill type, in which there was an opening entirely through the crown (Fig. 509), the post being set in the crown with amalgam or cement, and then cemented to the root.

The above two types are becoming obsolete, having been largely replaced by crowns of the Justi or Davis types having a hole in the base extending part way to the incisal edge or occlusal surface. (Fig. 510.) These crowns are ground to fit the tooth root, a post is cemented into them and the crowns then cemented to the roots.

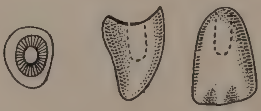
Fig. 510

These crowns are applicable to almost any case, but, except for temporary work, should not be used without banding the root, as an unbanded root carrying a crown is liable to be fractured.

Another crown which is easily made and produces a good effect, is known as the Downey crown. The cap and post is made of iridio-platinum. A facing is used, grinding it to fit and building up the lingual side with porcelain.

The crown generally known as the Richmond crown was made by grinding a pin facing to the floor of the cap, backing it with pure gold or thin platinum, waxing it to the cap, investing and soldering. This crown was very common a few years ago, but it has lost its popularity, except as an abutment for bridgework, and is being replaced by all-porcelain crowns. A crown with a metal backing can never be as artistic as an all-porcelain crown. The metal back destroys the translucency of the porcelain. In certain lights, the matching in shade and shape may be perfect, but in another light, or viewed from a different angle, the shade may be poor and the crown present a dull, lifeless, unnatural appearance.

Another feature in favor of an all-porcelain crown is its strength. An all-porcelain crown, if it is properly made and mounted, is far stronger and less liable to fracture than is a facing crown, however well made.

In all restorations, there must be a thorough understanding of the anatomical relations and of the directions of the stress which any tooth may have to withstand under normal or abnormal conditions, and the crown must be made in accordance with these conditions.

Under normal conditions, the stress on the molars and bicuspids of the upper jaw is upward and outward, the inward stress being comparatively slight. On the cuspids and incisors, the stress is outward and forward.

In the lower jaw with the molars and bicuspids, the stress is downward and inward, although the lateral stress is probably not as great as it is in the upper series.

With the six anterior teeth, the stress is backward and inward, while the shape of the arch is such as to prevent their being forced out of their normal position, each tooth or root acting as a keystone to support the whole arch.

The size and shape of the roots are also to be considered in all restorations. A root with a broad face presented in the direction of greatest stress, and having good length, will give far greater resistance than a shorter or smaller root.

The length of the crown which the root will have to support must likewise be taken into consideration. A long root will safely carry a longer crown than will a short root, as the leverage would be much greater on the short root with a crown of the same length.

It can be set down as a safe rule to follow, that the length of the crown should not be greater than the length of the root which is to carry it. There are exceptions to this rule in the case of bridges having several abutments. One or more of these roots may be shorter than the crowns they are to carry, as the other roots will help to support the weaker ones and there will be no undue strain.

The length of the cusps too is an important factor. If these are too long, a leverage is exerted which will soon bring about the destruction of the root, especially if it be carrying a single crown.

ESSENTIALS TO SATISFACTORY BRIDGEWORK.

General Considerations.—When consulted regarding the advisability of inserting a piece of bridgework, there are three fundamental factors to be considered; the number, position, and condition of teeth or roots available as abutments. The whole story of requirements for this work may be summed up in these few words: If the available teeth or roots are lacking in number, or are unsatisfactory as to position or condition, an essential to success is wanting, and the work is contraindicated.

There are certain mechanical and scientific principles governing this work and these same principles are involved whether we are placing a bridge in the mouth or across a river. There must be sufficient number of abutments to carry the weight which will be imposed upon it, and their position and condition must be such as to give stability to the structure, and to withstand any strain to which it may be subjected, otherwise it will collapse.

Partial Dentures vs. Bridgework.—In a very large percentage, probably in the majority, of mouths where partial dentures are now worn, bridgework could be used to much better advantage, and would be far more serviceable than are the dentures. Partial dentures are always decidedly objectionable and are to be avoided if possible. The dentures almost invariably injure the soft tissues and the adjoining teeth, the pressure gradually forcing the gum away from the necks of the teeth, which are abraded by the constant movement of the dentures, and in many instances this results in their loss. This is especially true where the denture is of small dimensions, carrying but one or two teeth.

In every case, or at least all but the simplest, it is best to take plaster impressions of the mouth and make accurately articulated models, trimmed so that they may be examined from every point of view, both from the inside as well as the outside. These models should be studied carefully before deciding on any definite line of operation.

The number, position, and general condition of the teeth being satisfactory, the success of a crown, or of a bridge, depends entirely upon the preparation of the teeth, or roots, which are to serve as abutments. By this preparation is meant not simply the mechanical trimming of the teeth or roots for the reception of the bands or posts, but it begins at the beginning with the treatment of any pathological conditions which may be present, the devitalizing and removal of the pulp, and the sterilizing and filling of the canals. This will be considered in the succeeding chapter.

PREPARATION OF ROOTS.

Under this heading are included, first, the therapeutic measures necessary to secure the continued health of all the dental tissues and their supports; and next the mechanical preparation necessary to form the root into a resistant base to which a crown may be fitted with exactitude.

During the past few years, the members of the dental and medical professions have been much disturbed by the attitude taken by some members of both professions regarding the devitalization of teeth.

1. There are some who assert that no tooth should ever be devitalized for any cause whatever.
2. Others contend that any tooth, in which the pulp is dead and where a radiogram shows the slightest disturbance in the apical region, should be removed immediately.
3. Again there are some extremists who take a very decided stand against the retention in the mouth of any tooth or root in which the pulp from any cause whatsoever has been devitalized, even when the tooth is perfectly firm and comfortable and where the radiogram shows absolutely not the slightest indication of a diseased condition.

These objectors find justification for their views in the readings of radiograms of the mouths of patients in which there are devitalized teeth and roots.

Indeed, from the showings, they have some reason for their opinions, but because pathological conditions arise, due to bad work and faulty technic, it is no more reason for a general condemnation of any and all treatments of the pulp than it would be to condemn certain surgical operations because some surgeons are unskilful and perhaps do more harm than good.

If, as the result of an injury to a leg or an arm, the bone becomes necrosed, would any sane surgeon advise the immediate amputation of the diseased member without an effort to effect a cure? He would not. Neither should a diseased tooth or root, which might be of the greatest value to the patient, be sacrificed without giving it every chance to become a useful member of the group of dental organs.

Of course there are many teeth and roots in which there has been such extensive destruction of tissue as to show at a glance that there is no hope for them, and such teeth should be removed at once, as they are a menace to the health of the other teeth and to the general health of the patient.

There are many other teeth, however, which show diseased conditions and which it would be a crime to extract without first striving to bring them to a healthy state. A great many teeth, in which the radiogram shows quite a marked disturbance in the apical region, will respond to treatment and become sound and healthy and do their work in a perfectly satisfactory manner for many years and without any recurrence of the original trouble.

The crown and bridge specialist comes in contact with any number of such cases, but if all of these teeth had been condemned without an effort to save them, incalcuable harm would have been done and many patients would have been deprived of bridges and crowns which have proven of inestimable value to them for many years and which have brought them health and comfort.

If no tooth in which the pulp is dead, even where the radiogram shows a perfectly healthy condition of the root and surrounding parts, should remain in the mouth, what is to be done with a tooth which has an exposed, inflamed and aching pulp, or one where through an accident the crown has been broken off? Are such teeth or roots to be sacrificed? They must be, if we are to follow the advice of the extremists who call for the removal of all devitalized teeth.

To extract such teeth would, in the writer's opinion, be malpractice, and the ruthless following out of such a practice would result in untold harm, far more harm than has been caused by the conditions which already exist.

The question is, what can be done to remedy or to bring about an improvement in these conditions?

One remedy is the acquirement of a higher degree of skill on the part of the operator and a special study of this work, under the direct supervision of experienced and skilled operators, would greatly reduce the danger of trouble due to unskilful operations.

The introduction of the roentgen-ray machine has been of wonderful value to the dentist and, by its use, these operations have been greatly simplified and there is no longer the excuse for poor root work, for every step can be verified and if the operations are done aseptically, good results should be secured.

Another way in which good results might be accomplished, is to have this work done by a highly qualified specialist. We have men who specialize in root work, devitalizing, treating and filling and also in the treating and filling of diseased roots.

This has worked out very satisfactorily in many instances to the personal knowledge of the writer.

Is it ever advisable or justifiable to devitalize the pulp of a tooth in order to utilize the tooth or root as an abutment for a bridge?

Bridgework, if used only where it is indicated and if it is properly constructed, is far more effective and enables the patient to masticate far more perfectly than is possible by the use of any partial denture which can be made and with practically no danger of injury to the remaining teeth, as is the case where a partial denture is used. No partial denture can be made which so nearly restores the lost formation of the dental organs as a properly constructed and perfectly articulated piece of bridgework.

If a vital tooth is needed as a support for bridgework, and if the work is skilfully and thoroughly done, it is perfectly proper and justifiable to devitalize it and there will be no ill-effects from having such a tooth in the mouth. There is far less liability of trouble from such a tooth than there would be from properly preparing and crowning a vital tooth or from placing a huge inlay capable of supporting such a bridge in a vital tooth.

Before undertaking the devitalization of any pulp, one or more radiograms should be taken of the roots in order to determine whether the tooth in question can be utilized and whether the canals can be opened, enlarged, treated and filled to the apex. If the radiogram shows that any of the roots are so distorted that it is impossible to open them to the end, of course there should be no thought of devitalization, as such a tooth would be sure to give future trouble.

When about to devitalize a pulp, a radiogram should be taken before beginning the work, after the canals have been opened, broaches or wires should be placed in them and a second radiogram taken to determine whether they have all been opened to the apex. One or more of the roots may be curved and the wires may not have gone to the end as in Fig. 511. If this is the case, another effort should be made by curving the end of the broach so as to follow the curve of the canal (Fig. 512) and working until the end of a fine broach just passes through the foramen and another radiogram taken. If this shows that the canal is thoroughly opened, it is prepared for filling. The canal or canals should be enlarged sufficiently so that a fair-sized canal point may be used in filling, as, if the canals are very minute, it is practically impossible to fill them properly.

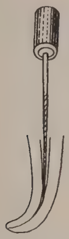

FIG. 511

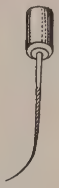

FIG. 512

After filling, another radiogram is taken to verify the work and if this shows that any canal is not perfectly filled, the filling is removed and the canal refilled and verified as before. This all takes time, but if every step of the work is carried out carefully and conscientiously, there will be no future trouble.

THE CAUSE OF SOUND TEETH DISCOLORING AFTER PULP DEVITALIZATION.

If the operation of devitalizing the pulp, and the after-care of the tooth have been properly done, there will be no discoloration. The discoloration of a tooth from which the pulp has been removed is due, not to the fact that the pulp of the tooth has been devitalized, but to the improper treatment of the tooth after pulp devitalization.

Quoting from his own experience, the writer does not recall a single case in which a tooth has become discolored after removing the pulp, but he has seen and treated many such cases, and has invariably found unmistakable evidence of the manner in which this condition was brought about.

In any of the anterior teeth the tooth is opened from the lingual or palatal side, or through a cavity, perhaps, on the mesial or distal side, drilling in the direction of the apex. The pulp is removed through this opening and the canal cleansed and filled. Usually it will be found that this part of the work has been well done, but the operator has not gone far enough in his work to prevent the trouble. As will be seen in the illustration (Fig. 513), the horn of the pulp extends far up into the crown of the tooth, while the opening has been made far below it. The result is that this extension of the pulp remains in the tooth after the canal and cavity have been filled, as in Fig. 513, where it decomposes, and in time the tooth structure becomes infiltrated with this putrescent matter, causing the discoloration.

The writer does not remember, and has no record of ever having opened up a discolored tooth where he has not found the conditions as described above.

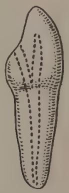

Fig. 513

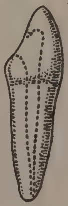

Fig. 514

After the canal has been opened, the pulp chamber should be enlarged sufficiently near to the incisal edge of the tooth to permit the removal of every particle of pulp tissue. This can be done with a rose bur in the right-angle handpiece, working from the lingual side, and opening it up enough so that the extreme apex of the pulp chamber can be reached (Fig. 514). After the pulp has been enitrely removed, the cavity is thoroughly sterilized and filled with cement of any suitable color.

Although, if the work of devitalizing the pulp and filling the tooth be properly done, there will be no discoloration of the crown, there will always be a slight difference in the opacity, owing to the removal of dentin and the placing of the cement lining, which may render it slightly noticeable in certain lights, or when viewed from certain angles. This will be especially true if the tooth so treated is standing next to its mate, as would be the case if the pulp of one of the central incisors was devitalized. With the cuspid, there are so many teeth between it and the corresponding tooth on the opposite side of the mouth, that even a marked difference in color would not be in the least conspicuous. The following may be set down as a rule which should invariably be observed:

Where there is a choice of teeth, in one of which the pulp is to be devitalized to serve as an abutment for a bridge, *always devitalize the pulp of the tooth which stands farthest away from its mate.*

In the case of a lost lateral incisor, the cuspid and central incisor being in equally good condition, the cuspid should be used as the abutment, but if the central incisor is badly decayed or broken, then of course it will be policy to utilize it.

PULP DEVITALIZATION.

When about to devitalize the pulp of a tooth, there are several questions to be considered. The first of these is, in which of the methods that may be employed is there the least danger of irritation or injury to the retentive structures of the tooth? Second, in what way may the operation be done with the least pain to the patient? Third, how can it be most quickly and easily accomplished?

There are several methods and agents employed for the devitalization of the pulp, almost any one of which may be indicated under certain conditions. Among the agents employed for this purpose, arsenic was one of the earliest and also the one most generally used but has been gradually abandoned for other methods, although there are still some dentists who employ it. It is the one too which requires the greatest care in its use; is dangerous in unskilled hands, and is uncertain in its results both as regards pain to the patient and effectiveness. When its use has been decided upon, the method advised by Dr. James Truman will be effective, and it will seldom be attended by pain if his directions are carefully followed. A very small quantity of arsenious acid is mixed with iodoform, using oil of cloves as a vehicle and applying it to the exposed pulp on a small pellet of cotton. This is covered with a small cap of tin or aluminum, to prevent pressure on the pulp, and the cavity is sealed with gutta-percha or cement.

If the arsenic is applied directly to the pulp, it should be left in for a few hours only. If on opening the tooth again, it is found that it has not taken effect, another application may be made and this may be repeated if it is found necessary to do so. The action of the arsenic should not be permitted to extend all the way to the apex, but should be watched carefully and the pulp removed while there is still some life at its apical extremity. If there is no exposure, it is safer to make the application only a little below the enamel, or in the bottom of an existing cavity, just sufficiently deep to allow its being properly sealed in, rather than to make an exposure. The arsenic will act upon the dentin to densensitize it, so that in a few hours it will be sufficiently obtunded to enable the operator to expose the pulp without pain to the patient, after which, if he so desires, he can anesthetize and remove the pulp by any method which he may see fit to employ.

It should always be borne in mind that arsenic or an anesthetic will not act at all, or will act very slowly, upon an inflamed or congested pulp. If the pulp is in this condition, a dressing of oil of cloves or eugenol and sulphate of morphia is one of the best applications for relieving the pain and reducing the inflammation. A pellet of cotton is saturated with the oil of cloves or eugenol and from one-fortieth to one-thirtieth of a grain of the morphia is added to it. This is placed in the cavity in contact with the pulp and allowed to remain until the pulp is quiescent, which will usually be in from twenty-four to forty-eight hours, after which the arsenic or the anesthetic may be applied.

It is good practice to avoid the use of arsenic if possible, as there is always a chance of disturbances following its use such as arsenical pericementitis or even necrosis. The former of these may not manifest itself immediately, but sooner or later it is liable to appear either in a mild or severe form. If the arsenic is not sealed in perfectly, especially if the cavity extends below the gingival margin, necrosis is likely to ensue, which in some cases might have far-reaching effects. Some patients are peculiarly susceptible to this poison; and in the mouths of such, arsenic applied for a few hours only would be sufficient to devitalize the pulp completely, while in others it might remain for days or even weeks with seemingly little effect. In the former case, if it were left in the tooth for any great length of time, the chances are that its action would not be limited to the pulp itself, but would extend through the foramen and beyond the apex and involve the surrounding tissue. Especially would this be true if the foramen were somewhat enlarged. The danger would be greater when using it on a young, than on an elderly patient, as the root may not be fully developed, and the foramen may be widely patulous, in which case carbolic acid, creosote or some such agent is indicated. Cases also occur in which there is an imperfection in the walls of the root canals. A condition of this kind is fortunately very rare as it is one which it is impossible to foresee and guard against, and if arsenic is used, disturbances which may result in serious injury to the patient are unavoidable. It sometimes happens that the pulp will resist the arsenic and repeated applications will have no effect, in which event, some other agent must be employed.

Pressure Anesthesia as Used in the Removal of the Pulp.—With the introduction of pressure anesthesia the work of devitalizing and removing pulps has been very much simplified.

A number of instruments have been devised for anesthetizing the pulp through the crown of the tooth. These are in the form of powerful syringes, by means of which great pressure can be obtained.

An opening is made through the enamel to the dentin with a small bur, corresponding in size to the point of the syringe, which is then placed in this opening, and pressure applied to force the anesthetic into the tooth structure. If the point fits the hole accurately, in a majority of cases a satisfactory anesthesia will be obtained. Many times, however, the syringe point does not accurately fit the hole through the enamel, the anesthetic escapes around it instead of being forced into the dentin, and in consequence the application is ineffective.

Another, and in fact the original method, is to place the anesthetizing solution into a carious cavity, or an opening made for the purpose, and over this a piece of unvulcanized rubber is placed. This is pressed into the cavity with a strong instrument, forcing a sufficient quantity of the solution into the dentin to produce a satisfactory anesthesia. This latter method is the one preferred by the writer. If the proper technic is carefully followed, positive and satisfactory results may be confidently expected.

One, and perhaps the principal cause of failure in applying the pressure in this manner, is that the operator uses for carrying the solution a piece of cotton entirely too large for the purpose. The cotton is dipped into the anesthetic solution, placed in the cavity and the pressure applied. If the mass of cotton is too large to be covered by the rubber, some fibers are left projecting from the sides of the cavity; when the pressure is applied, these give vent to the solution, so that instead of its being forced into the tooth structure, it escapes by following the cotton fibers extending over the edge of the cavity.

It must be remembered that, in applying pressure anesthesia in any manner whatsoever, the pressure must be direct and positive, without any leakage, in order to force the solution into the dentin or into the pulp.

Sterile Field for Operation.—Before applying pressure anesthesia the greatest care must be used to insure a sterile field for the operation. If there is a gangrenous or septic condition of the body or any part of the pulp, this must first be corrected and the parts made as thoroughly aseptic as possible. If this is not done, septic gases or matter may be forced through the apical foramen and cause serious trouble.

In order to devitalize a perfectly sound tooth, an opening should be made directly in line with the axis of the tooth so as to gain direct and free access to the pulp. The first step is to grind through the enamel. This is best done with a small stump carborundum point, or a diamond disk or drill. The engine should be run rapidly and the tooth kept flooded with ice-water, which prevents heating, and also acts as a slight obtundent. By using ice-water freely, the enamel can be quickly pierced, sometimes even continued until the pulp is exposed, with but little or no pain at all to the patient. In the anterior teeth this opening is made on the palatal or lingual side, while in the bicuspids and molars it is made directly through the center of the tooth. (Fig. 515.)

The rubber dam is applied as soon as the enamel has been penetrated. If from any cause this cannot be done, napkins or cotton rolls may be substituted to keep the secretions of the mouth from encroaching upon the field of operation.

The instruments needed should be ready at hand, convenient for instant use. These should include broaches for removing the pulp from the canals, a large spear-pointed drill, large coarse rose burs, a large cross-cut fissure bur, and one or two sharp spoon excavators, which may be used to remove the body of the pulp.

A large spear-pointed drill is the best instrument for drilling through the dentin (Fig. 516). It should not be used for drilling through the enamel, as the latter is so hard that it quickly dulls the point, with the result that it not only takes more time, but the increased pressure necessary to make it cut, heats the tooth, and renders the operation much more painful than it would be otherwise.

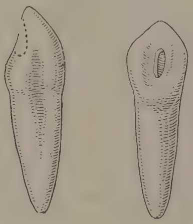

Fig. 515

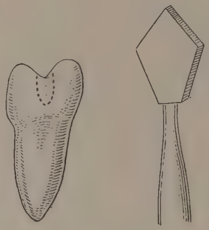

Fig. 516

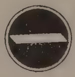

Fig. 517

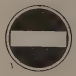

Fig. 518

It is very rarely these instruments are well made as they come from the dental depots. They are generally too thick and at the cutting edges are not backed off sufficiently to cut well. They can be greatly improved by first grinding them very thin and then backing them off so as to leave a good sharp-cutting edge which will cut deeply and cleanly into the dentin and clear itself readily. (Fig. 517.) If the edges are thick and straight across and have not this clearance (Fig. 518), the drill will drag and heat, causing pain and rendering the operation more lengthy and difficult.

The enamel having been pierced, the rubber dam is applied, the tooth thoroughly dried, and the point of the drill placed on the dentin pointing in direct line with the axis of the tooth's root, with the engine running at high speed. As soon as the patient experiences pain, it is time to begin the use of pressure anesthesia.

There are a number of different preparations used in the devitalization or the anesthetizing of the pulp. Novocain seems to be a favorite agent with many dentists. The writer, however, has had excellent results from using the pure crystals of cocain in conjunction with some fluid as a vehicle, usually favoring a local anesthetic solution.

The local anesthetic, which seems to work best, and in fact, has been found by the writer superior either for extracting or wherever a local anesthetic is indicated, is as follows:

Acid, carbolic		10 gr.
Cocain hydrochloride		10 gr.
Atropin sulphate	2 per cent solution	10 min.
Nitroglycerin	1 per cent solution	10 min.
Adrenalin chloride	sol. (1 to 1000)	10 min.
Distilled water		2 oz.

After using and recommending it for many years, the writer has neither seen nor heard of any ill results following its use. It is, however, wise to use this and all allied preparations with caution, using no more than is absolutely needed.

In making the application, only a very minute piece of cotton should be used. A piece no larger than one-quarter the size of a pin-head is ample for the largest tooth. This is dipped in the anesthetic solution and then a slight excess of the cocain, which has previously been finely powdered on a glass slab, is taken up on the cotton and placed at the bottom of the cavity.

A piece of soft, unvulcanized rubber is then placed over it and pressure brought to bear with an instrument which nearly fills the opening. It must be remembered that in order to obtain perfect results there must be a positive pressure, and if the instrument be too large or too small it will not do the work as well. If a positive pressure is obtained, it is not necessary to keep it up longer than from twenty to thirty seconds. The vulcanite and the pellet of cotton are then removed, the opening dried, and the spear-pointed drill is once more used.

If the tooth becomes sensitive again before the pulp is exposed, the operation is repeated. It will be found, however, that, as a general rule, with one or two applications of the anesthetic in a healthy tooth, the exposure can be obtained without pain to the patient. After the exposure has been made, the final application should be made directly on the pulp, the pressure being kept up for about thirty seconds, when it will be found that the pulp has been completely anesthetized and the pulp chamber can be opened and the pulp removed.

It should be remembered that in using the anesthetic with pressure, the pulp is not devitalized, but simply anesthetized, and if the operation of removing the pulp is long continued, sensation may return. In multi-rooted teeth, when the canals are very minute and difficulty is experienced in opening into them, sensation may return to the pulp in one or two of the canals while the pulp is being removed from the others. This necessitates a second application.

If the tooth has been broken down by decay and a cavity exists through which the pulp is accessible, this cavity may be utilized. The disintegrated tissue, however, must first be thoroughly removed, for its presence will hinder the action of the drug. The anesthetizing solution on a small pellet of cotton is then placed in the cavity, and pressure applied as before described.

POSITION OF THE PULP CANALS.

Before undertaking to remove the pulps from devitalized teeth, the operator should have an accurate knowledge of the anatomy of the teeth. He should know the number of roots which each tooth should possess, and where to look for entrance to the canals on the floor of the pulp chamber of a normal tooth, and should also be able to form some idea of their approximate size.

Some of the canals are frequently very minute and difficult to locate, and a knowledge of their normal position is helpful in finding them.

All operations are more quickly and thoroughly done if the operator works systematically, and by some well-considered rule. This applies with much force to the operation of locating and opening the pulp canals.

Opening into the Pulp Chambers of Molar Teeth.—In enlarging the entrance to the pulp chamber do not fear to make a large opening. It is impossible to get into the different canals in the molars, and cleanse them as they should be cleansed, through a minute opening in the crown of the tooth. A large opening should be made through the crown, and the pulp chamber opened to its full size so that the entrance to every canal is easily accessible. It does not weaken the tooth to do this. As a chain is only as strong as at its weakest point, so with a tooth, and this point is where the pulp chamber approaches the sides of the tooth (Fig. 519).

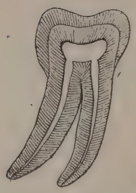
FIG. 519

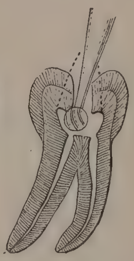
FIG. 520

After drilling into the pulp chamber, the enamel at the entrance to the cavity should be removed with a cross-cut fissure bur, but the use of this bur should not extend to the pulp chamber. The best instrument to enlarge this, is a large rose bur, passing it through the opening and under the ledge, or as it might be termed, the roof of the pulp chamber, and pulling the bur toward the occlusal surface (Fig. 520).

This should be continued until the explorer shows that the sides of the cavity are flush with the sides of the pulp chamber and the explorer slides smoothly into it.

A fissure bur, an inverted cone, or any square-ended instrument should not be used in doing this work, as they are sure to strike the sides of the pulp chamber, leaving ledges or grooves on which the broaches will catch, and render the locating of the canals much more difficult; whereas, by using round burs only, the floor of the pulp chamber is not marred, and there will be no roughness to interfere with the instrument, which will then much more readily find the openings to the different canals.

Locating the Pulp Canals of the Upper Molars.—As a rule, it is more convenient to first locate the palatal canal in the upper molars. This canal is much larger, and occupies a position which renders it more easy of access than are the others, and it is rarely that there is any trouble in locating it at once and removing the pulp.

The writer has found that the best instruments for locating the canals are the short, knob-handled broaches of the Kerr or Downey type (Fig. 521). These instruments are made of triangular steel wire, twisted, and brought to a fine point. They are much stronger and are less liable to be broken than are the barbed broaches. Then, too, being shorter, without barbs, and with just the right degree of stiffness, they admit of a far more delicate sense of touch than does a long and very flexible instrument.

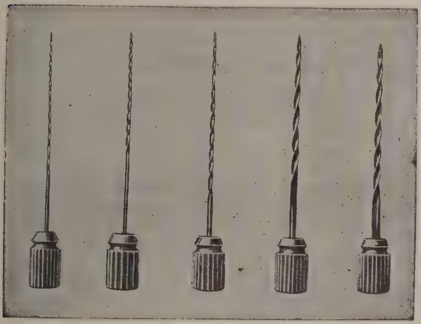

FIG. 521—Kerr broaches.

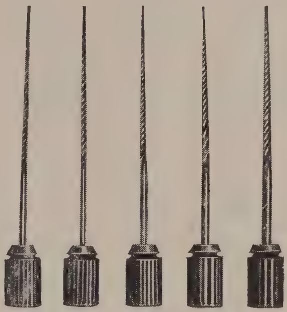

FIG. 522.—Kerr canal files.

When using these broaches, if conditions permit, the rubber dam should always be in place, but if this is not possible, the mouth should be protected with napkins or cotton rolls, so as to keep the parts dry, and also, if the broach should slip from the fingers, to prevent its dropping into the throat.

The palatal canal having been located, the next one to look for is the anterior buccal. To reach this, the handle of the broach is passed distally and palatally, reaching the point of the instrument far forward toward the mesio-buccal corner of the tooth, and if the pulp chamber has been carefully opened, there will be very little difficulty in finding this canal. It sometimes happens that the entrance to this canal is located so far mesially that it will be necessary to cut almost through the mesio-buccal corner of the tooth in order to get free access to it.

There still remains the distal canal to be accounted for. If, when, the instrument is in the anterior buccal canal, it is slowly withdrawn, sliding the point lingually through the groove in the floor of the pulp chamber, as a rule the point will find the entrance to this canal with but very little difficulty. These canals are often very minute and extremely difficult to open. For this the Kerr, or Downey, broaches are used, beginning with the small ones, and working very carefully; using little or no force to push them into the canals, but allowing them to work their way easily as the broach is rotated. The sodium and potassium preparation may be used to advantage in such cases, working it in with a broach. Sodium dioxide is also used for this purpose, and will at times prove quite effective. Again, a 50 per cent solution of sulphuric acid may be of assistance. A little of it, indeed, may be sealed into the root and allowed to remain until a subsequent sitting, when it frequently will have so softened the contents of the canal that the broach will readily find its way to the end.

Fig. 523 will give a fair idea as to the position in which these canals are generally found, the large palatal canal *c* being about in the center of the palatal root and the anterior buccal canal *a* being found very close to the anterior buccal corner. The distal canal *b* will be found nearly on a line between the anterior buccal and the palatal canal, or slightly distally to it, but very rarely at right angles with the other canals. Occasionally, the two buccal canals have a common opening into the pulp chamber (Fig. 524), and in such cases, the entrance to the separate canals will be found just a little below the pulp chamber floor.

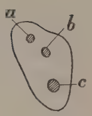

FIG. 523

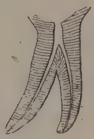
FIG. 524

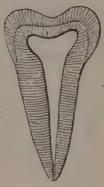
FIG. 525

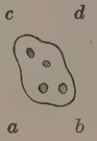

FIG. 526

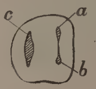

FIG. 527

Occasionally, but very rarely, an upper first or second molar will have but a single root. When this is the case, the canal will be very large, the pulp chamber sloping from all sides toward the center of the tooth, and the canal tapering to the apex. (Fig. 525.)

Again we may find one of these teeth which has two roots. When this is the case the buccal canal is usually as large or even larger than the palatal canal. If, on opening the tooth, the instrument drops readily into the buccal canal, midway between the mesial and distal sides of the tooth, and if it is very much enlarged throughout its entire length, it is a fairly certain indication that there are no more than two canals in the tooth. If, on the contrary, this canal is very much constricted, it indicates the existence of another canal.

Where the molar has four roots, the two palatal canals will generally be larger than the two buccal, and one will be almost directly behind the other following the line of the arch (Fig. 526, *a* and *b*), although neither of them will be as large as where there is but a single palatal root. The two buccal canals will be about in normal position. (Fig. 526, *c* and *d*.)

Locating the Pulp Canals of the First and Second Lower Molars.—Normally, the lower molars have but two roots; almost invariably, however, there are three distinct canals which must be cared for, one in the distal and two in the mesial roots. While in reality there is but a single canal in this root, it is so constricted between the buccal and lingual openings that this part of the canal is almost obliterated, the space between the walls of the canal at this point being so slight that there is practically no pulp tissue between them. (Fig. 527.)

The distal canal *c* being the one most easily accessible, is naturally the one first looked for. The canal being much larger than those in the anterior root, and the position being favorable, it is readily located and the pulp easily removed.

The canal next sought for is generally determined by the inclination of the tooth, if this be excessively to the lingual, it would naturally be the lingual canal (Fig. 527, *b*), as this position of the tooth renders it more easy to reach. In locating the canals in this root, the rule in regard to the order in which they are opened is not followed as closely as it is in locating the buccal canals in the upper molar. At times, the buccal canal (Fig. 527, *a*) is more quickly and easily located than the lingual.

Very frequently the distal slope of these roots is such that it will be necessary to cut the mesial wall of the tooth almost to the gum line in order that the instrument may follow the line of either the mesial or distal canals. (Fig. 528.) The buccal canal of the mesial root is the principal offender in this respect, and it is sometimes necessary to cut the mesio-buccal corner of the tooth entirely away before an entrance into the canal can be effected.

The mesial canals are frequently so constricted and tortuous as to render it extremely difficult to open them all the way to the apex. At times it is necessary to spend hours, or even days, to get these canals properly opened and enlarged, but one of them, at least, *must* be opened all the way to the end of the root.

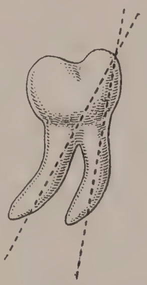

FIG. 528

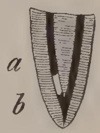

FIG. 529

These canals sometimes diverge bucally and lingually as they leave the pulp chamber, and converge as they approach the apex, having a common foramen (Fig. 529).

If it is practically impossible to entirely open but one of these canals, and the other has been opened to within a very short distance of the apex, the little pulp tissue remaining in this small space between the filling that is to be placed in the canal which has been opened to the end of the root, and the filling which will be placed as far down in the other canal as it can be placed (Fig. 529, *a* and *b*), will hardly do any harm.

The canals, of course, must be perfectly sterilized, particular attention being paid to the one which has not been opened entirely to the apex. The canal from which the pulp has all been removed is filled very carefully, making certain that it is filled all the way to the end. The remaining canal, which has not been fully opened, is saturated with a solution of zinc chloride, after which it is filled as far as possible, so that only a little thread of coagulated pulp tissue is left in the root. This is entirely cut off and isolated so that the danger of subsequent trouble is very remote. If the operator desires, this canal can be filled with some mummifying paste, but it is only in cases of this kind that such a filling is indicated.

Occasionally these teeth, as in the case of the upper first and second molars, may possess a greater or less number of roots than normal, and there may be but a single root or there may be several. There is rarely any trouble in opening the pulp canal of a single-rooted lower first or second molar all the way to the end of the root. As in the case of an upper molar, the pulp is always very large and peg-shaped, so that it is easily removed.

The third molars are especially lacking in uniformity as to the number of their roots; they may have but a single root or there may be many. These roots frequently converge and may be fused together, forming one large peg-shaped root in which there may be several canals. These canals are frequently so small and tortuous as to render it impossible to open all of them their entire length. In such cases, the operator must be satisfied with something less than the ideal, so far as filling them to the end is concerned, but should make every effort to insure that they are at least perfectly sterile.

It is this uncertainty in regard to their condition which sometimes renders them unserviceable as abutments for bridgework. In such teeth it would be impossible to give any fixed rule as to opening of the canals and removing the pulp, except that the pulp chamber should be fully opened so as to give free access to all the canals which it is possible to find.

Locating and Opening up the Pulp Canals of the Upper Bicuspids.—The upper first bicuspid, is a double-rooted tooth with the canals opening on the buccal and lingual side. The canals of these roots are sometimes quite constricted, and require considerable time to open them all the way to the end. With a little perseverance and the use of the sodium and potassium, or sulphuric acid, this can, however, generally be accomplished.

Occasionally the root has a very sharp curve near the apex. Indeed, it is at times bent almost, if not quite, to a right angle with the rest of the root. In such cases it may be impossible to remove all of the pulp tissue. As much as possible is taken away with the broaches, using the sodium and potassium, or the sodium dioxide, and then trust must be placed in antiseptic treatment to prevent future trouble. There are times when it may be advisable to amputate these curved root ends before using the teeth as abutments.

The upper second bicuspids sometimes show exactly the same conditions as are to be found in the mesial root of the lower molars, namely, a single root, but practically two canals, which should be treated in a similar manner to those of the lower molars. These canals may be entirely separate and present all the appearance of a first bicuspid, but if they are opened all the way to the end, it will be found that they unite at the apex in one common foramen, and if one of the canals be filled, the filling will be forced a little distance up into the other canal.

A two-rooted second bicuspid occasionally is found, but this is rare and need not be especially considered, as the treatment would be the same as for the first bicuspid.

Locating and Opening up the Pulp Canals of the Lower Bicuspids and Anterior Teeth.—The lower bicuspids have but a single root, and the pulp is approached directly through the center of the cusp.

All of the six anterior teeth, both upper and lower, are opened from the lingual side, as near the center as possible, and it is very rarely that any trouble will be encountered in removing the pulp and thoroughly sterilizing the canals.

The mesial roots of the lower molars are frequently very difficult to open. While there is but one root, in nearly every case there are practically two very constricted canals (Fig. 527), a buccal and a lingual, which diverge or run parallel as they open from the pulp chamber, but frequently unite at or near the apex, making exit by a single foramen. (Fig. 529.) It is sometimes impossible to open both of these to their full length, but every effort should be made to get at least one of them clear all the way to the end of the root. For if one of the canals is opened to the apex and the foramen perfectly closed, the pulp which remains in the other canal is entirely cut off, as in Fig. 529, *a* and *b*, and the danger of subsequent trouble from it is very remote.

After one canal is filled, the remaining canal is saturated with chloride of zinc and filled as far as possible, so that only a little thread of coagulated pulp tissue is left in the root.

The buccal canals of the upper molars also, are frequently so small that it is very hard to open into them for any distance. The twisted three-sided broaches of the Kerr type or canal files (Figs. 521 and 522), are excellent for enlarging these constricted canals. A drop of sulphuric acid will very often materially assist the operator in opening them.

Occasionally the tooth may possess more or less roots than the normal number. In every case the pulp chamber should be well opened and the floor and sides should be carefully examined with a fine explorer for the aperture of the canals. It is a mistake to undertake to remove the pulp with only a small opening in the crown of the tooth, especially if it is to be crowned. It does not weaken it to open it to the full size of the pulp chamber, as the crown of the tooth is only as strong as that part which has the least sectional area and this is at or near the floor of

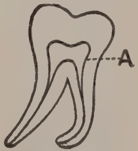

FIG. 530

the pulp chamber (Fig. 530, *A*), consequently the opening may be made to the full size of the floor of the pulp chamber without weakening the tooth in the least.

The third molars are especially lacking in uniformity as to the number of their roots, and the canals are frequently so small and tortuous as to render it impossible to open them more than a short distance. In such cases the operator must be satisfied with something less than the ideal results which he would desire so far as filling them to the end is concerned, but he should always be assured that they are at least perfectly sterile.

FILLING OF ROOT CANALS.

Satisfactory and permanent results in the filling of pulp canals is not so much a matter of the materials employed as it is the manner in which these latter are inserted. Of course, some of the materials in use are better than others, and it is probable that gutta-percha and oxychloride of zinc are more extensively used than any others.

The writer believes that gutta-percha points make the best root filling of anything that can be used.

An excellent method of filling with gutta-percha is as follows: As a preliminary measure to the operation, it is understood that the rubber dam is to be applied to the tooth if this is possible, and if not, napkins or cotton rolls are to be used to keep the field of operation dry. After the canal has been thoroughly cleansed and dried, a gutta-percha point is selected of a size corresponding to that of the canal to be filled, the point having been previously sterilized in a bichloride of mercury solution and fastened to the end of a canal plugger by heating the point of this instrument. A little oil of eucalyptus is introduced into the canal from the points of a pair of pliers or with a wisp of cotton twisted around a broach. The gutta-percha point is now dipped into oil of eucalyptus and then the tip of it into iodoform or aristol, after which it is placed in the canal and worked into it with a pumping motion, carrying it farther up as the oil softens the surface of the gutta-percha, until it becomes loosened from the plugger and is packed tightly into the root. In this way the canal can be more thoroughly filled all the way to the apex than by any other method. It does no harm if the patient winces a little during the operation, as that is a pretty good indication that the end of the root has been reached. Chloroform may be used in place of the eucalyptus, but the oil is preferable as it is of a healing, soothing nature, besides possessing antiseptic properties which persist in the canal for many years.

Where it is intended to enlarge the canal in order to insert a post as an attachment for a crown, the canal may be enlarged at once, with a reamer, to the desired size and depth, enlarging it to within about $\frac{1}{8}$ inch, or a little less, from the apex, before filling.

A very short gutta-percha point is then used, dipping it in eucalyptus and aristol, and just filling the apex, packing it tightly against the shoulder left by the reamer. (Fig. 531.) The canal is then wiped dry and the gutta-percha covered lightly with oxychloride of zinc.

Filling Pulp Canals with Enlarged Foramina.—Where the apical foramen is very much enlarged, as it will be in the case of an undeveloped tooth, gutta-percha is the only suitable material for filling, and care must be used so that no appreciable amount of the filling is forced beyond the apex. The exact length of the root is first ascertained by passing a hooked broach through the enlarged opening and marking the length with a small piece of rubber placed over the broach. (Fig. 532, *b*.)

It is always advisable to have at hand a series of different sizes of canal pluggers, from which one is selected which will pass into the canal only to within about $\frac{1}{8}$ inch, or a little less, from the end. (Fig. 532, *a*.) This can be determined by placing it alongside the hooked broach used for measuring its depth. A blunt gutta-percha point is now selected, slightly larger than the end of the canal plugger and a little shorter than the distance from the end of the plugger to the end of the canal. (Fig. 532, *c*.) This is attached to the end of the plugger, and is then dipped in eucalyptus and aristol and pressed firmly in place at the end of the root, the canal having been previously dried. The plugger is then loosened by rotating, after which the canal is washed and dried with alcohol and the gutta-percha is covered over lightly with oxychloride of zinc.

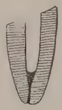

Fig. 531

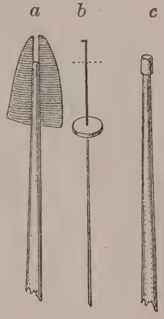

Fig. 532

The diameter of the gutta-percha point having been somewhat greater than that of the canal to be filled and also slightly shorter, it packs very tightly in place as far as the plugger point will carry it, and at the same time the contraction of the canal elongates it a little, so that the apex is perfectly closed. Then too, the plugger being of large size, renders it impossible for the filling to be forced beyond the point desired and through the foramen where it might act as an irritant.

A plugger of a smaller diameter than the apical foramen should never be used in filling these canals. An accident or a sudden movement of the patient might cause the filling to be forced through the end of the root, with no possibility of removing it.

If the entire length of the canal is to be filled, the operation will be very similar to the one described. The size of the foramen is ascertained with a suitable plugger. The plugger used for filling should be just large enough so that it will pass into the opening of the canal from the floor of the pulp chamber, not much more than $\frac{1}{16}$ inch. The size and length of the gutta-percha point is determined from these two pluggers and the hooked broach. It is made of a slightly larger diameter and a little shorter than the canal. After it has been dipped in the eucalyptus oil, it is packed tightly in place as far as the plugger point will carry it. The one-sixteenth of the canal remaining unfilled, is covered with oxychloride of zinc.

When chloropercha is used as a filler, a little iodoform or aristol is first put in the canal and the chloropercha pumped in with a broach, a fresh supply being added as the chloroform evaporates. When it is carried well into the canal a gutta-percha point may be forced into it, or fine wisps of cotton may be packed in with a small plugger, until the canal is filled. It is questionable if this will make as perfect a filling as the gutta-percha point, especially in the upper teeth.

The objection to oxychloride of zinc as a root filling is the irritating nature of the zinc chloride and the difficulty of limiting its action. If a little of it is carried beyond the apex, it will cause considerable pain and discomfort to the patient, and may sometime result seriously. Another objection to using oxychloride alone, especially in any of the teeth anterior to the molars, is the difficulty of opening up the canals at some future time for the reception of a pin, should it become necessary to place a bridge or crown the roots. This difficulty, however, may be overcome; after the canal has been pumped full of liquid cement, a gutta-percha point is inserted and forced to the end of the root.

PERFORATED ROOTS.

This is a difficulty which is frequently encountered, and the treatment of it is often very puzzling to the dentist. Where the perforation is at the apex, it may be treated and the root filled in the same way as a root with an enlarged foramen. If there has been much inflammation, a dry dressing of tricresol and formalin or of one of the essential oils and iodoform or aristol may be kept in the canal until the soreness has passed away, when the root may be filled in the manner already described. Where the perforation is of long standing, the root will probably be abscessed and the treatment of the case would come under the head of alveolar abscess.

Where the perforation is at the side of the root, it is quite likely that the soft tissues have grown into the cavity. This intruding tissue may be removed by excision, or it may be cauterized with trichloracetic acid, carbolic acid or iodine. Where the size of the growth is not great, the opening may be cleared by packing the pulp cavity tightly with dry absorbent cotton. This will expand as it becomes moist and force the gum tissues out. The sides of the opening should now be grooved or roughened so as to hold the filling in place, and the cavity is then wiped out with adrenalin chloride. If the perforation is not far below the gum margin, it often happens that a small flat-ended instrument may be passed under the gum and up the side of the root so as to cover the opening. If this be possible, the instrument is held in place against the root, the cavity dried thoroughly, and the filling packed tightly against the instrument.

Where the perforation is so far beyond the gum line that it is not possible to cover it, a little base-plate or high-heat gutta-percha is pressed into it and then removed. (Fig. 533.) This will show the exact size and shape of the perforation. If gutta-percha is to be used to stop it, the trial plug is trimmed so that it will come not quite to the outer wall of the root, leaving a slight excess on the inside. Adrenalin chloride will prevent blood or moisture from oozing into the cavity, which should be dried with alcohol and then wiped out with oil of eucalyptus or any other essential oil. The plug, which has previously been lightly fastened to the end of an instrument, is then placed in the opening and packed flush with the canal wall.

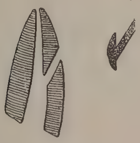
Fig. 533

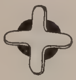
Fig. 534

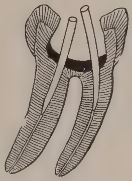
Fig. 535

Copper amalgam is one of the best filling materials for cases of this kind. In the one just described, the trial plug will show the amount which it will be necessary to use and the amalgam is packed into the opening, care being used not to force it beyond the outer wall of the root.

Where there is a large perforation in the floor of the pulp chamber, it is better first to cover it with a piece of thin, soft platinum (Fig. 534), and then to cover the floor of the pulp chamber with copper amalgam, keeping the entrance to the canals free by placing wires in them which have been oiled or wiped with vaseline or cocoa butter and after the amalgam has hardened, the wires are removed. (Fig. 535.)

FRACTURED ROOTS.

This is a troublesome condition of somewhat frequent occurrence, and it is often difficult to decide whether a root which has been split can be saved or will have to be extracted. The fracture of a root is often brought about by crowning without banding it and is most frequently either that of an incisor or a bicuspid. In the majority of cases where there is a bad fracture, it will be necessary to remove the root but sometimes it can be made to do good service for a number of years even if it has been split all the way to the apex. Where the root has been newly fractured and the gum tissue has not had time to crowd its way between the broken parts, they should first be drawn close together by placing a strong wire of 30 or 32 gauge over the stump and twisting it tightly in the same way as in taking the measurement for a band. (Figs. 536 and 537.) It should be forced up on the root as far as possible and if necessary, the gum can be slit on the labial side to allow its being carried to a sufficient distance under the gum. The root can then be prepared, a tightly fitting band made, and the crown constructed and cemented to the root. After the cement has thoroughly hardened, the wire ligature is to be cut away, and if the band has been properly fitted, the tooth should last for many years.

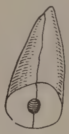

Fig. 536

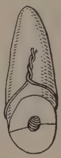

Fig. 537

In many cases where there is only a minor fracture, the part which is broken away may be removed and the band carried beyond the line of fracture.

PATHOLOGICAL RELATIONS.

The success of crowns and bridgework depends primarily upon the healthy condition of the teeth and roots which are to be utilized as supports, and pathological conditions and their treatment are of the greatest importance to one who is doing this work.

Every factor which has any bearing on the success or failure of this work must be carefully considered and nothing left to chance. If the teeth are loose or otherwise diseased, they should be carefully studied in order to determine whether through treatment, they can be brought to a healthy condition.

If this is impossible, then of course bridgework is not to be thought of, unless other teeth or roots which can serve in their place are available.

If a tooth is loose, it should be studied in order to determine the cause of the looseness and if the cause is removed, the tooth may return to a normal condition.

The most prolific cause of loosening of the teeth is malocclusion. It will be found that with every movement of the jaws, the tooth is forced out of position. By using articulating paper and grinding freely until the mandible can be moved in an direction without moving the tooth from its position, it may return to normal without further treatment unless there has been much destruction of the surrounding tissue.

Lack of occlusion is equally destructive. A tooth which has no antagonist and has nothing to do, will elongate and loosen and eventually be thrown out of the mouth, but restore the occlusion and give the tooth a proper amount of work to do, it will become firm and healthy and do its work satisfactorily.

Pyorrhea alveolaris, chronic nephritis and other systemic diseases may be responsible for loosening of the teeth, but these cases should be referred to a specialist and nothing in the way of bridgework should be undertaken, except on the advice of the specialist, or until a cure has been effected.

Putrescent Pulp Canals.—In treating a putrescent pulp canal the first step is to cleanse it mechanically as thoroughly as possible. The greatest care must be exercised in doing this so as not to force any of the putrescent matter or gas through the apical foramen. The instruments best suited for this purpose are the Donaldson canal cleansers. These instruments are barbed in such a manner that the barbs follow around the shaft in the same manner as does the thread on a right-hand screw, so that by rotating, the instrument is drawn into the canal without the necessity of using the slightest force.

The instrument is dipped in carbolic acid or other strong antiseptic, the point placed in the canal and the instrument turned slowly to the right. As it is carried into the canal it is frequently withdrawn and cleansed of the matter adhering to it, until the vicious matter is entirely removed. By working in this manner there is no danger of carrying any of the putrescent mass through the end of the root. It is of the greatest importance that not the slightest force be used on the instrument. After the bulk of the softened mass is removed, the sides of the canal are scraped with the same instrument until it is fairly well cleansed.

Sodium and potassium is then used, being carried into the canal with a fine instrument, burning out any of the disintegrated pulp tissue which remains in the root. This should be done thoroughly, and a little of the sodium and potassium left in the canal until a subsequent sitting. When the patient returns, the treatment with the sodium and potassium is repeated, after which the canal should be washed out with a solution of bichloride of mercury and peroxide of hydrogen. It is then thoroughly dried and filled.

In the absence of the sodium and potassium, formalin may be used, but this should not be sealed in the root, unless the foramen is closed, or is very minute, as it is an active irritant and may cause considerable pain and trouble.

Sterilizing a Pulp Canal with Formalin.—In sterilizing a pulp canal with formalin, the following method will prove effective: After the root has been as thoroughly cleansed mechanically as is possible under the existing conditions, it is dried with alcohol and the canal wiped out with a strong solution of formalin, from 10 to 40 per cent of the full strength of the solution, using a wisp of cotton twisted around a broach as a carrier. It is then dried with hot air or a heated root-drier, thereby driving the fumes of the formalin into the tooth structure. This operation is repeated a number of times until it is certain that the root has been thoroughly sterilized, after which it may be filled.

Where there has been a slight irritation in the apical region, it is a good plan to enlarge the foramen very slightly before treating, and a dry dressing of tricresol and formalin may be sealed in the canal and left for a day or two, to be repeated if necessary.

Where there has been an excessive and continued irritation, it is best to treat the case in a thorough manner, opening through the process to the apex, giving it the same treatment, indeed, as in the case of a dento-alveolar abscess, and then filling the root at once.

When, on opening into a tooth, the pulp is dried up and in a mummified condition, the canal should be given the same treatment and care as though the pulp were putrescent.

The same treatment should be employed in the case of cotton-filled roots, which are sometimes met with, without regard to the condition they may seem to be in, foul or sweet. In a majority of these cases the canals are in a putrid condition, and before being utilized they should be treated as advised for the canals of putrescent pulps.

PULP INFECTION AND TREATMENT OF RESULTANT CONDITIONS.

There are many causes which may bring about the death of the pulp and unless this condition is recognized very early and properly treated, trouble of a more or less serious nature is liable to follow.

There are cases where the pulp has become devitalized and remained quiescent for a number of years, the patient being unaware that there is anything wrong with the tooth, but this is not of frequent occurrence; more often the trouble becomes manifest within a comparatively short time.

With the infection and decomposition of the pulp tissue, the danger begins. A minute portion of this putrescent matter, or a little of the gas generated by it, finding its way through the apical foramen, will set up an irritation and inflammation; infection follows, resulting in the formation of a dento-alveolar abscess. This condition formerly was too often lightly considered, and an abscessed tooth looked upon as of minor importance, when in reality it is a grave condition and may cause serious pathological disturbances, and not infrequently death has followed from septicemia caused by absorption of pus.

Dento-alveolar Abscess.—This is one of the troubles with which the crown and bridge specialist is most frequently confronted. As a general thing, it is not difficult to effect a cure.

In this as in every step in crown work and bridgework, thoroughness is necessary to success, and unless one is willing to give the time and attention necessary to effect a cure, it is far better not to attempt it.

With the formation of pus around the apex of the root, there is a destruction of tissue extending in all directions, thus forming an irregular cavity or sac into which the apex of the root extends. (Fig. 538.)

As the amount of pus increases, it will gradually force its way through the alveolar process and gum tissue, thus establishing a fistula.

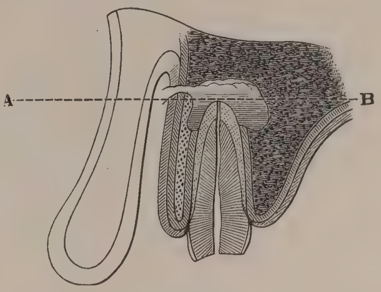

FIG. 538

If there is a cavity in the tooth through which the pus, after passing through the canal, may be discharged into the mouth, there will be no external fistula; this is termed a blind abscess.

The treatment of an abscess which has no outlet for the pus excepting that through the root of the tooth, should never be undertaken. It is practically impossible to force the remedies through the apical foramen into the pocket or sac of the abscess, or to cleanse it thoroughly and remove the débris without having an external fistula. Treatment through the root may relieve the trouble temporarily, but it is liable to recur at any time.

In the case of an acute dento-alveolar abscess, where there is a fistula established, a cure can generally be effected quickly and easily.

For many years the writer has had almost uninterrupted success in the treatment of this trouble by using the following method:

The canal is first cleansed as thoroughly as possible mechanically, using Donaldson's canal cleansers, or instruments of that type, and scraping the sides of the canal thoroughly so as to remove every particle of diseased tissue which can be reached.

It should then be ascertained beyond doubt that there is an open fistula through which the remedies will readily flow, and this can be done by using distilled water or a mild antiseptic solution.

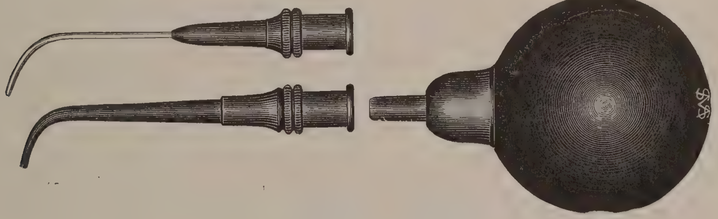

FIG. 539.—Bulb syringe.

Treatment of Acute Dento-alveolar Abscess.—In the treatment of acute dento-alveolar abscess, it is necessary that a suitable instrument for injecting the remedies be used. A rubber-bulb syringe, with platinum point, known as an abscess syringe, is most useful for this purpose. (Fig. 539.) The capacity of the bulb of this syringe is one-quarter of an ounce.

In order to insure the remedy being forced through the canal and out through the fistula, it is necessary to use a packing, preferably of rubber. This is very easily made by forcing the needle through a piece of heavy separating rubber of sufficient size to entirely cover the opening in the tooth or root, letting the end of the needle extend a little beyond this rubber packing, as in Fig. 540.

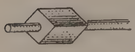
FIG. 540

The point is then introduced into the opening in the canal or tooth and the rubber pressed tightly over the opening and around the needle with a pair of cotton-pliers. This will effectually prevent the fluid from escaping at this point, and will insure its reaching the place where it is needed.

The abscess cavity is first washed out with sterile water so as to ascertain that there is a free vent, and a saline solution is forced very slowly through the root and out of the fistula.

The solution first used is followed by the standard solution of aromatic sulphuric acid. This solution is used in its full strength as given in the United States Pharmacopœia and contains about 10 per cent by bulk, or 20 per cent by weight, of sulphuric acid.

The amount of the aromatic sulphuric acid used is from $\frac{1}{4}$ to $\frac{1}{2}$ of a syringeful, or from $\frac{1}{16}$ to $\frac{1}{8}$ ounce, or at times even more than this.

The point of the syringe is inserted into the canal and the rubber packing pressed tightly against the tooth, as with the first solution, and the acid forced through very slowly. This helps to destroy any remaining diseased tissue and acts as a stimulant. The acid should be met, as it comes through the fistula, with a syringeful of a saturated solution of bicarbonate of soda, so as to counteract, or neutralize, the action of the acid before it comes in contact with the teeth and the soft tissues of the mouth. The bicarbonate of soda should be used freely, as much as 3 or 4 syringefuls during the injection of the acid, and afterward the mouth should be rinsed freely with the same.

After the acid has been used, the root should be filled at once. If it is left open for any length of time, infection may recur, and it will be necessary to repeat the operation, as there is a serious risk of reinfection as long as the root remains open.

After treating an abscess in this manner and filling the root canal, it will generally require from ten days to two or even three weeks before the parts are finally healed. During this time there will be a discharge of blood and serum through the fistula, presenting the appearance of pus, but this is a perfectly natural condition, as there is a normal sloughing of the disintegrated tissues which must be expelled as the parts are healing.

At times, when the edges of the wound are fresh, the fistula may close up at once, or within two or three days, but it will break out again, and this may be repeated several times; it will not heal finally until all of the sloughed tissue has entirely disappeared and healthy granulations have replaced it.

It is very rarely, in the case of an acute abscess, that it is necessary to repeat this treatment, but it should be remembered that the cure depends entirely upon the thoroughness with which the operation has been performed.

Establishing a Fistula.—If there is no external opening, and the abscess has been draining through the pulp canal of the tooth, it is necessary to establish a fistula. Occasionally, by sealing the opening through the tooth for a time, Nature will establish one with comparatively little discomfort to the patient, but if this cannot be done, it becomes necessary to make an opening through the gum and process.

A spear-pointed drill is best suited for this purpose; it should be of a large size, sharp, and perfectly sterilized.

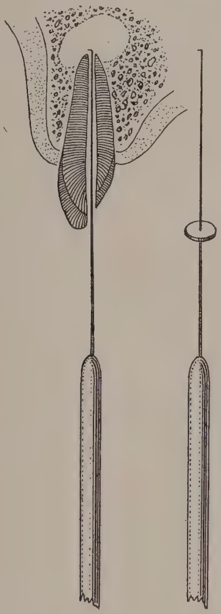

Fig. 541

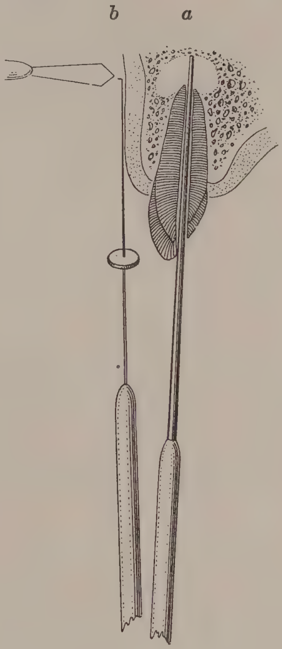

Fig. 542

Locating the Apex of the Root.—It is necessary to first locate the apex so as to know exactly where to drill. The foramen is slightly enlarged in order to ascertain the exact length of the tooth or root. This can be done with a small hooked broach, passing it through the canal and catching the hook over the end of the root. A small piece of rubber dam is pressed down over the broach to the incisal edge of the tooth or against the end of the root (Fig. 541). The broach is then removed. The position of the rubber indicates the exact distance from the end of the root or the incisal edge of the tooth to the apex. A perfectly straight broach is then inserted, being of a larger size than the one used in measuring the length of the root, one that will wedge in the canal with the end passing through the foramen into the pocket, the handle extending beyond the incisal edge of the tooth, as in Fig. 542, *a*. By following the line of this broach the exact direction of the canal is indicated.

By placing the hooked broach over the gum and bringing the piece of rubber dam even with the incisal edge of the tooth, or with the end of the root, it will show exactly how far from the incisal edge to drill in order to strike the pocket or the end of the root (Fig. 542, *b*).

Using these two as a guide, and following the direction of the broach which is wedged into the root, the drill can be directed so as to reach with certainty the apex. This operation can be quickly and easily performed by using a general anesthetic, but it is very rarely that a general anesthetic is indicated, as the time required is so short that a local anesthetic, used hypodermically, will give satisfactory results.

Painless Insertion of the Hypodermic Needle.—With patients who are of a highly nervous temperament, or where the tissues are extremely sensitive, the pain caused by the insertion of the hypodermic needle is at times almost as great as would be the pain of the operation if it were performed without an anesthetic. The pain caused by the forcing of a hypodermic needle into the soft tissue may be greatly lessened if, when the syringe is filled, the flattened side of the point of the needle is pressed tightly against the gum and the end of the finger pressed over the point, at the same time pressing on the plunger. It is held thus for a moment and gradually the needle is forced into the tissue, the pressure on the plunger being kept up all the time. In this way the tissues are anesthetized in advance of the needle, and the operation rendered almost painless. The gum should be first cleansed and dried with alcohol, and it is well to touch it with iodin before attempting to insert the needle.

The opening through the gum to the process can be made with a lance, a trephine, or by using a sharp spoon-shaped excavator; with the latter, by dipping it in carbolic acid and scraping the gum a little then dipping in the acid again and repeating this operation until the process has been reached. It is possible thus to go through the tissue to the process without drawing blood, and causing very little or no pain to the patient.

It is possible to take a drill, with the edges of the blade very sharp, and drill directly through the gum, but unless the edges of the drill are very sharp, there is danger that the gum tissue may be caught and twisted around the drill and badly torn. The use of the lance is the quickest and easiest method, making a straight incision on a line with the long axis and over the apex of the tooth, or, if it is desired, a crucial incision may be made.

The point of the drill is placed over the apex of the root as indicated by the broaches which are serving as guides.

The engine should be run very rapidly and the aim be to strike the end of the broach, which is wedged in the root canal, at about the point where it emerges through the foramen.

Some operators, especially among the younger practitioners, are timid and dread performing an operation of this kind, but it is very simple and is quickly done, not requiring more than a few seconds at the most.

As soon as the pocket is entered, a fistula is established, through which the remedies can be forced freely.

Chronic Dento-alveolar Abscess.—When an abscess has become chronic, extending over a period of several years, a necrotic condition in the apical region is established, and a portion of the root will also be necrosed. This necrosed area must be entirely cut away and the diseased portion of the root removed in order to effect a cure.

Treatment.—The apex is located in the manner already described. The incision in the gum should be larger than where simply establishing a fistula. It should be at least ½ inch in length. A large spear-pointed drill is first used and is followed by a large coarse rose or pear-shaped bur to enlarge the opening through the process and bur away the necrosed bone. The necrosed bone must be entirely removed, and during the operation, frequent examinations should be made with an explorer or excavator, and the burring continued as long as there is the slightest trace of necrosed tissue. This can readily be determined by the sense of touch. The necrosed bone has a coarse or honeycombed texture, readily recognized by the instrument, while the healthy bone is smooth in comparison.

After the diseased tissue is entirely removed, the wound is washed out with sterile water, and is then given the same treatment as already described in the case of an acute abscess using aromatic sulphuric acid, after which the root is filled at once.

Amputation of the Root End for the Relief of Dento-alveolar Abscess.—In amputating the apex of a tooth root, some operators advise the use of a fissure bur, cutting straight across the root, thus removing the end in one piece.

In the writer's opinion, this is an error, as the piece is left in the pocket and at times the part cut away is so large that it can only be removed by greatly enlarging the opening through the process. If it is not removed, it will act as an irritant and there will be a recurrence of the trouble.

A large rose bur or pear-shaped bur is indicated for this work, starting from the apex and burring away the root gradually as far as is necessary; the root is thus reduced to fine particles which are easily washed out from the pocket. The after-treatment is the same as that for an acute abscess.

Many operators prefer filling the root before amputating. When this is done, the filling is burred away with the root. With this method, there is always a possibility of loosening the root filling, and thus leaving a chance for future trouble.

The writer believes that in an operation of this kind, the most satisfactory and certain method is to fill the root after amputating. The

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length of the root is taken with a hooked broach, and a canal plugger is selected which will reach only to within about $\frac{1}{8}$ inch of the end, the same as in the filling of a root with an enlarged foramen.

The pocket is first treated the same as for an acute abscess, being washed out with aromatic sulphuric acid.

An instrument having a broad flat end is passed through the opening in the process and pressed tightly over the end of the root, being held firmly in that position with the left hand. The canal is then thoroughly dried.

A gutta-percha point, which has previously been selected and which is slightly larger than the plugger which is to be used, the length being about that of the canal between the end of the plugger and the end of the root, is fastened to the plugger point by heating. This is dipped in eucalyptus oil and packed tightly against the instrument which covers the end of the root. By filling the root in this way, we may be quite sure that the filling is firm, and there will be no liability of leakage.

If the crown of the tooth is good, and the canal is not to be used for the reception of a post, the entire canal may be filled with the gutta-percha, packing it tightly against the instrument covering the end of the root.

If the wound is large, it is better that it be packed lightly with antiseptic gauze, which will act as a seton and keep the part drained. This dressing should be changed every two or three days and the wound washed out with an antiseptic solution. Healthy granulation will quickly begin and the depth of the wound will diminish as it is filled in with healthy tissue. The treatment should be kept up until the wound has become filled with healthy tissue to within about $\frac{1}{8}$ or $\frac{3}{16}$ inch of the opening. The dressing and washing may then be discontinued. Healing will be complete within a very short time, if all of the necrosed tissue has been removed. If this does not take place, it is evidence that there is still remaining some diseased tissue, and further treatment, looking to its removal, is needed.

MECHANICAL PREPARATION OF TEETH AND ROOTS.

The vital relations of the teeth or roots having been satisfactorily settled, the success of either crowns or bridges depends more largely upon the proper preparation of their abutments than upon any other mechanical factor. If these are not properly prepared, the results will be disappointing to both dentist and patient, however well the prosthetic portion of the work may be done. A large proportion of failures may be traced to this source and too much care and study cannot be given to the subject. Other parts of the work might perhaps be slighted without seriously affecting the permanency of the operation, but lack of proper preparation of the abutments will always be at the expense of the permanence and safety of the fixture. The trimming of a tooth may seem to be a simple operation, but it is not. It takes time to do it properly and this time must be given.

We shall undertake to describe in detail the preparation of the teeth and shall begin with those which are to receive full-gold crowns, either single, or as abutment pieces for bridgework. We shall take first the lower molars.

Viewed from the buccal side, the approximal contour of these teeth is very great. Starting just below the gum line, it swells outward, until at the point of contact with the adjoining teeth, the tooth is from one-quarter to one-third larger than at the neck. Viewed from the occlusal surface, the tooth is oblong in shape.

This tooth when properly trimmed, is nearly square in shape, with the corners rounded, being slightly broader on the mesial side and nearly flat, while on the distal side, it is somewhat convex. This is owing to the difference in the size and shape of the two roots. The buccal and lingual sides are nearly straight lines, with a slight depression near the middle, from the bifurcation of the roots. (Fig. 543.) This description will apply more especially to the first and second molars, the third molar being subject to greater variation in shape than the others.

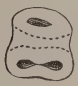

FIG. 543

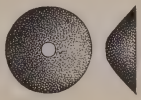

FIG. 544

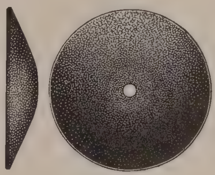

FIG. 545

The lower molars are, perhaps, the most difficult teeth in the mouth to trim. The bulk of the cutting in these, as in all of the teeth, will be on the mesial and distal surfaces, the contour being greatest at these points. This contour must be entirely removed to a point about $\frac{1}{16}$ inch below the gum line, so that when the band is passed over them, it will hug the neck of the tooth tightly. For doing this work cup- or saucer-shaped disks, either diamond, or thin corundum, or carborundum and rubber, are best adapted. (Figs. 544 and 545.) The tooth is examined with an explorer (Figs. 546 and 547) to determine how much of the contour it is necessary to remove. The edge of the wheel is placed at the proper point on the occlusal surface and nearly the whole of the contour can be taken away with one cut, using plenty of water and holding the wheel very steady. (Fig. 548.) If it is found that there is still some projection at the cervical margin, it may be removed with the face of the wheel. (Fig. 549.)

For the buccal and lingual sides, when using the straight handpiece, a thin flat disk, or an inverted cone, either of diamond or carborundum, may be used. (Figs. 550, 551 and 552.) These should be from $\frac{3}{8}$ to $\frac{5}{8}$ inch in diameter.

The most of the cutting here, will be on the lingual side, as these teeth generally incline toward the tongue. The trimming of these surfaces may be most easily done from the side on which the tooth to be trimmed is located. If it is on the right, the operator should stand on that side, if it is on the left, he should stand at the left of the patient. The buccal side may be ground with the face and the lingual with the reverse side of either the flat wheels or inverted cones. (Figs. 551, 552, 553.)

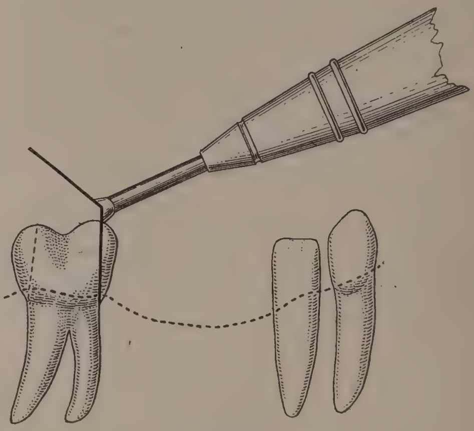

Fig. 548

Fig. 546

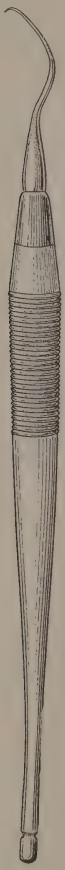

Fig 547

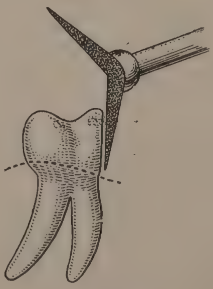

Fig. 549

The anterior buccal corner may be nicely rounded to the desired distance under the gum with the inverted cone or disk, using the face and rotating from side to side, as in Fig. 550. The posterior lingual corner is reached with the reverse side of the same wheels (Fig. 551), as used for the lingual side, while for the posterior buccal, the inverted cone must be used from the opposite side of the mouth.

The anterior lingual corner is the most difficult of any to reach, but most of this may be taken away with the face side of a saucer-shaped wheel, rotating it from the opposite side of the mouth. Very coarse emery-cloth disks on account of their flexibility are of great use in finishing these corners.

With the right angle handpiece, small diamond disks from $\frac{3}{8}$ to $\frac{1}{2}$ inch in diameter (Fig. 544) will be found very useful, especially for the corners. In some places which cannot be reached with wheels or disks, the corners or ledges may be removed with enamel cleavers or scalers. The No. 3 S. S. White special scaler, may be used. (Fig. 554.) The explorer should be constantly employed to detect the slightest irregularity or projection of the surface by sliding it down the face of the tooth, and the least shoulder or ledge must be removed, so that when the band is passed over the tooth and under the free margin of the

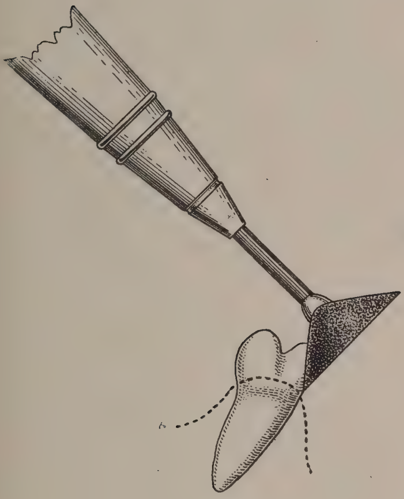
Fig. 550

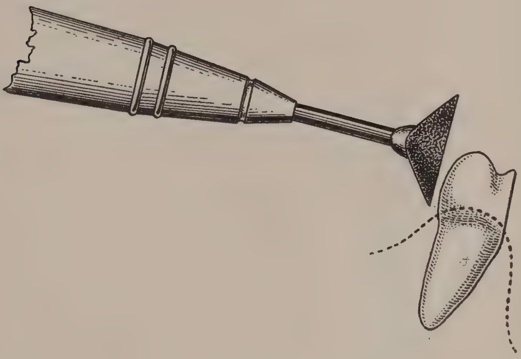
Fig. 551

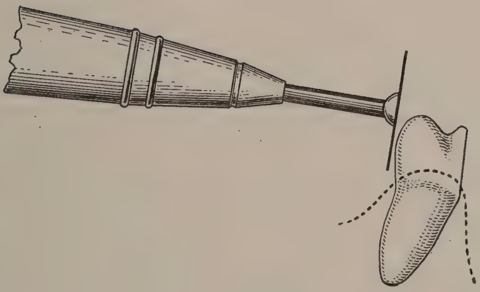
Fig. 552

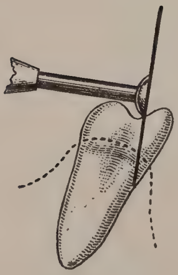
Fig. 553

gum, it will hug the neck tightly. A fissure bur or a finishing bur may often be used to advantage for locations which it is almost impossible to reach with anything else.

In the lower jaw where the first molar has been lost, it will generally be found that the second has pitched forward so that its only point of contact with the upper teeth is at one of the distal cusps. In cases of this kind there will be little or no cutting on the distal side of the tooth; but on the mesial side at the masticating surface, it is necessary to cut far back toward the center of the tooth in order to make it nearly parallel with an anterior abutment as in Fig. 555. The cup-shaped disks are used here as in the former cases. The lingual and buccal sides and the corners are to be treated in the manner already described.

Where there is an excessive leaning of the tooth toward the tongue, as in Fig. 553, there will be no cutting at all on the buccal side, but a great deal on the lingual, the most of which can be done in one cut with a thin disk.

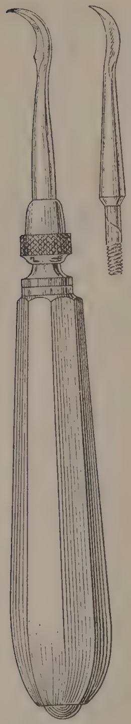

Fig. 554

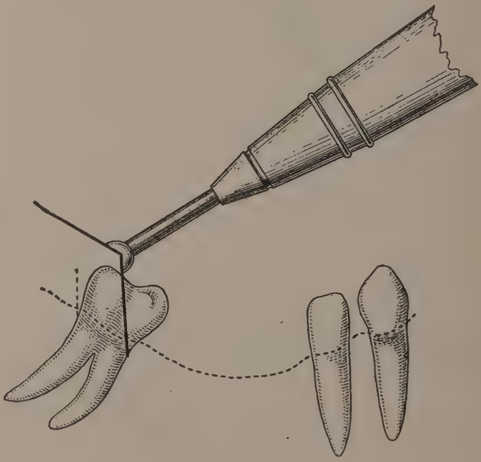

Fig. 555

It is far better to trim too much than too little. If a tooth is cut away more than enough to remove the contour, the band can rest on the ledge or shoulder and the cement may be entirely removed, so that there will be no irritation, but if enough has not been taken away, when the crown is in place, the band will stand away from the neck of the tooth and cut into the gum and the cement will present a rough, jagged surface to the soft tissues, causing irritation and inflammation which may eventually result in the loss of the tooth.

The bicuspids are trimmed in the same manner as the molars, but in most cases a straight or flat disk may be used on the mesial and distal sides. The point of difficulty here, as in the molars, is the mesiolingual corner and this will have to be trimmed largely with the scaler or the small diamond disk in the right-angle handpiece.

At the masticating surfaces of the teeth, enough tooth structure should be ground away to permit the placing of a strong thick cusp, especially where it is to serve as a support for a bridge. This can best be done with a very coarse grit square-edged wheel.

The shape of the upper is very different from that of the lower molars. Observed from the masticating surface, they are somewhat diamond-shaped with the corners rounded, the greatest diameter being from the anterior buccal to the posterior palatal corner. (Fig. 556.) This is generally the shape of the third molars, but these teeth are subject to more frequent variations in form than the others of the upper series.

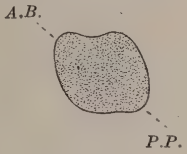

FIG. 556

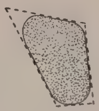

FIG. 557

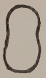

FIG. 558

The typical form of the upper molars, after being prepared, is not at all like that of the lowers. It is somewhat triangular in shape, with the long dimension on the mesial side. (Fig. 557.) It is broader at the buccal side than at the palatal, because there are two buccal roots and but one palatal. This shape may vary at times and the palatal be as large or even larger than the two buccal roots, but this is an abnormal condition and will be readily discovered by the use of the explorer.

It infrequently happens that the first or second molars will have but two roots and when this is the case, they will both be of about the same size. Very rarely they may have but one root. The third molars are more uncertain, as there may sometimes be but one root, at other times several.

The trimming of these teeth is much easier than that of the lower molars. The bulk of the cutting will be on the mesial and distal surfaces, the greater part of which can be taken away with one cut of the disk already described. For the buccal and palatal surfaces and for the corners, the cup-shaped disks and inverted cones are indicated. The coarse emery-cloth disks will be found almost invaluable in rounding the corners, especially the posterior buccal and palatal.

The bicuspids are trimmed in the same manner as the molars. These teeth after being prepared are somewhat egg-shaped in cross-section, being long and narrow from buccal to palatal side, broader at the buccal and having slight depressions on the mesial and distal sides. (Fig. 558.) This description applies chiefly to the second bicuspid, as it is seldom that a full-gold crown, on account of its conspicuousness, should be placed farther forward in the mouth than that tooth.

We now come to the eight anterior teeth. All crowns for these teeth should be of porcelain or porcelain faced. The method of their preparation to receive a band is somewhat different from that of the other teeth, the work being done almost entirely with enamel cleavers and scalers.

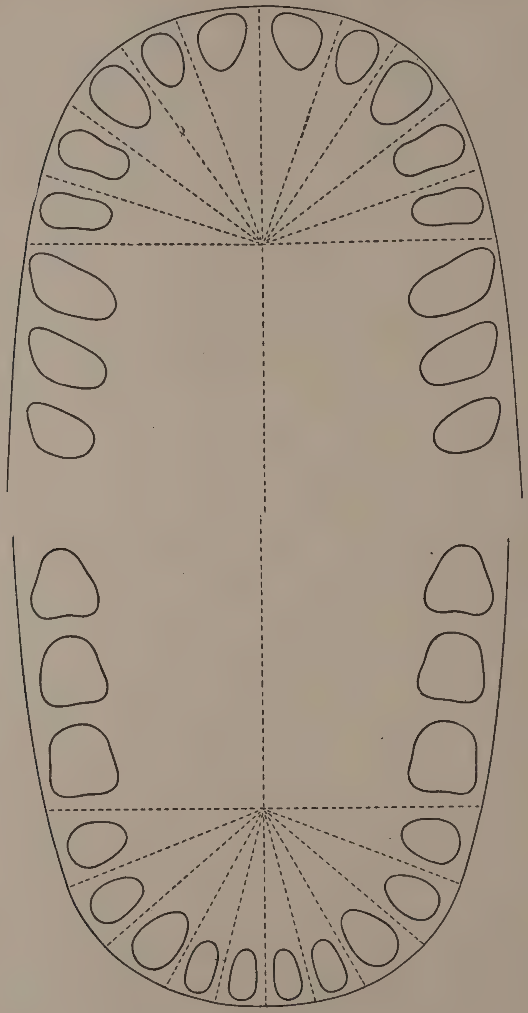

Fig. 559

The typical shape of the roots in the upper jaw, anterior to the molars, the central incisors excepted, after being prepared for the reception of the band, is oval, being broadest at the labial side and narrow at the palatal. This must of necessity be the case, in order that they may be properly accommodated in the arch. (Fig. 559.)

The first bicuspid has very much the same shape as the second. The shape of the canines and lateral incisors is almost a true oval, but the central incisor roots, while of the same general ovoid form, are more distorted, being somewhat triangular in shape. The longest side of the triangle is on the mesial and the shortest on the distal side of the root. The labial side is somewhat flattened and generally inclines outward toward the median line.

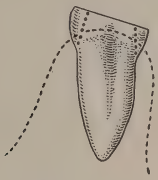

FIG. 560

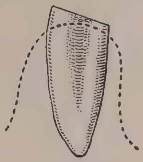

FIG. 561

In preparing these teeth, they should be left about $\frac{1}{16}$ inch above the gum line until after the root has been trimmed and the band has been fitted. (Fig. 560.) It will be found that the greatest sectional circumference of the roots of these teeth is at the point of junction of the enamel with the dentin. (Fig. 560.) The enamel must be entirely removed, and if this is properly done, unless there has been a recession of the gum, the root will be of the proper shape for the reception of the band (Fig. 561), which should take the place of the enamel and fit the root tightly.

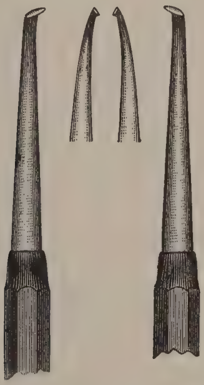

FIG. 562

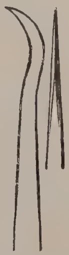

FIG. 563.—Enamel scaler.

For removing enamel, the enamel cleavers (Fig. 562), and the scalers are best adapted. On the mesial and distal sides thin disks may often be used to advantage. For the labial and palatal sides, the No. 3 scalers are the best, as the curve of the instrument adapts itself nicely to the root. These instruments should have short heavy handles

(Fig. 554, p. 604) so as to afford a sure grip for the hand, and should be held in such a guarded and protected manner that there will be no chance of the instrument slipping and injuring the soft tissues. For the approximal sides, where the teeth are very close together, the No. 7 scaler (Fig. 563) will be very useful. At the basilar ridge, where the enamel is very thick, the enamel cleavers can be used to start with, afterward finishing with a No. 3 scaler. Where the gum has receded beyond the edge of the enamel, the root is trimmed in the same manner, the sides being made parallel or slightly convergent.

The roots of the lower anterior teeth are the same general shape as those of the upper, with the difference that the bicuspids are narrower proportionally bucco-lingually and the incisors are flattened mesio-distally. These roots are trimmed with scalers in the same manner as the upper teeth.

SHAPING THE FACE OF THE ROOTS AND ENLARGING THE CANALS.

The further preparation of a root in the anterior part of the mouth, after the enamel has been removed, varies according to the style of crown which is to be used. In any case where an anterior root is to be banded, it should be left standing about $\frac{1}{16}$ inch above the margin of the gum until after the root has been trimmed and the band has been fitted. For taking the measurement of the root, Kirk's dentimeter is the most suitable instrument. The wire is placed over the end of the root and forced as far under the gum as is possible and twisted until it hugs the root tightly. It is then removed, the loop cut, the wire straightened out and the band cut to the measurement and united either by sweating or soldering. It should be festooned to follow the gum line perfectly, so that it will go an equal distance below the margin all around. After the band has been fitted, it is removed and the root cut to its proper length. It should be cut at least $\frac{1}{32}$ inch and in many cases, nearly or quite $\frac{1}{16}$ inch below the gum line on the labial or buccal side, so that when the crown is placed on the root, the band will be completely hidden. (Fig. 564.) Where a Richmond crown is to be used, the root is left standing out from the gum on the palatal or lingual side as in Fig. 564. If porcelain is to be used, it is necessary to have as great an amount of body as possible to give strength to the crown, this being of necessity a very fragile material. In this case the root should be cut so as to follow the line of the septum of the alveolar process, leaving it higher in the center and low both labially and lingually as in Fig. 565.

In opening up the root for the pin, if it is enlarged on a line with the canal, the pin will in most cases come wholly or partially under the facing, necessitating the cutting of the facing to accommodate it, or if the facing is to set close to the floor, which is desirable in the six anterior teeth, the cutting away of the end of the pin, so that the only attachment it will have to the crown will be to the thin floor of the cap. This applies more particularly to Richmond crowns on the six anterior roots, either single or those to be used as abutment pieces for bridges. The better procedure is, after the canal has been enlarged in a direct line, to incline the reamer toward the palatal side of the root, thus sloping the canal in that direction. (Fig. 566.) Now by bending the pin slightly, there will be ample room in front of it for the facing, the pin coming up behind it as in Fig. 567.

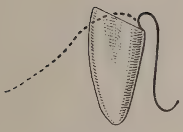
FIG. 564

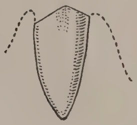
FIG. 565

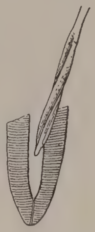
FIG. 566

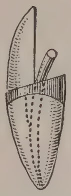
FIG. 567

For porcelain crowns, the root should be enlarged only on a line with the canal, especially in the upper jaw where the strain is all outward, and the facing grooved to receive the pin, so as to have as great an amount of porcelain on the palatal side of the crown as possible, to give the needed strength. (Figs. 568 and 569.) In the lower jaw where the strain is inward, the pin may be set farther in toward the lingual side of the root.

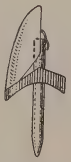
FIG. 568

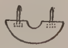
FIG. 569

REQUISITES OF A CROWN.

Artificial crowns should, as nearly as possible, restore the appearance and function of the natural teeth. Moreover, by their presence they should afford no more opportunity for the action of disease-producing agencies than when a natural crown is upon a pulpless root. This rule is impossible of exact fulfillment, but it is possible that by a correct artificial crown, properly placed upon a healthy root, the possibilities of disease processes arising may be reduced to a minimum and by an improperly made or placed crown the probabilities of subsequent disease are increased.

All crowns must rest firmly upon the face of the root upon which they are placed. The contact must be at all points of the edge of a crown with the tooth surface. If of porcelain, it must correspond in shape, size, shade, and position with its fellows, and must subserve the purposes of a crown in mastication.

There should be at no part any projection which can form part of a pocket, nor any point which can act as an irritant to vital tissue. The line of junction between root and crown should be clean and clear, so that neither the surface of the root projects beyond the edge of the crown nor the edge of the crown beyond that of the root.

If a shell or collar crown, the gingival edge of the band must be in close contact with the root surface. It should extend far enough beneath the margin of the gum to grasp the root firmly, but should not extend to the alveolar border. A limited portion of pericementum is destroyed in trimming a root, and the band should not extend beyond this point. As the band represents or replaces the upper border of enamel, it should not extend much beyond the depth of the enamel line unless the gum should have receded from about the tooth.

Porcelain crowns should have the porcelain protected against fracture, either by the inherent strength of all-porcelain crowns themselves, or of sufficient bulk to supply the strength required.

For posterior teeth the details as to correspondence of size and contour are equally important, and in addition their articulating surfaces should have such an arrangement of cusps and sulci that the normal masticating surface is restored.

TYPE SELECTED.

As a general rule, no root anterior to the first molar should be crowned with an all-gold crown. None of the incisors or canines should show any but a porcelain surface. Any healthy root if of good size and structure will safely carry a crown, but except in temporary work, the root should be banded to protect it from fracture.

TEMPORARY CROWNS.

The pin and plate crowns or crowns of that type when there is no reinforcement to prevent the fracture of the root, are practically all alike and are suitable only as temporary crowns. They are very simple and are easily and quickly made. They are applicable for the front of the mouth or the bicuspids, especially where the teeth are broken down and it is necessary to restore them temporarily while permanent crowns are being made. Patients will appreciate it very much if temporary crowns are made before removing the broken down crown so that as soon as these are cut off, others are ready to go in place of those removed. It is good practice never to let a patient leave the office with a crown missing in the front of the mouth. A careful plaster impression is taken and an accurate model is made of the teeth which are to be replaced. After the model has well hardened, the gingival margin is carefully outlined and facings or crowns are selected. The plaster teeth are then cut off and a hole drilled in the plaster in the center of each root to a depth of about $\frac{3}{8}$ of an inch. The stumps are cut just about to the gum line on the labial side and to within a little less than $\frac{1}{16}$ of an inch on the lingual side. The facings or crowns are then ground, waxed in place and a wall of plaster is built on the labial side, as in Figs. 570 and 571, coming a little short of the incisal or occlusal edge. After the wall has hardened, the facings or crowns are removed, the posts or pins placed in the holes and the crowns, or facings adjusted. If facings are used, it is very likely that the facing may partly cover the opening in the root. In this case the entrance to the canal can be sloped a little lingually as in Fig. 566 and the pin bent to clear the facing (Fig. 567), or if the tooth pins are far enough from the face of the root, the facing can be ground to clear the pin, which is bent lingually (Fig. 567). If the tooth pins are close to the canal, the facing can be grooved between the pins as in Figs. 568 and 569.

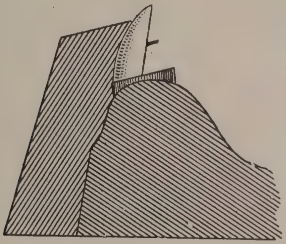
FIG. 570

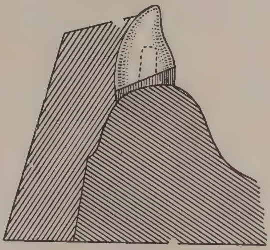
FIG. 571

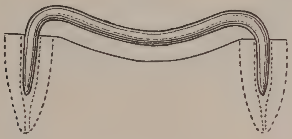
FIG. 572

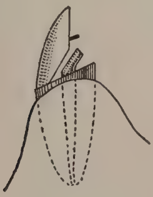
FIG. 573

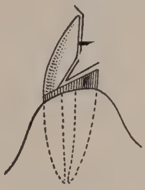
FIG. 574

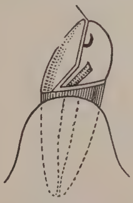
FIG. 575

A backing and floor of one piece of pure gold 36 gauge is then made, bending it sharply at the lower edge of the facing and letting it extend a little above the incisal edge. (Fig. 574.) A hole is made through the floor close to the facing; if the facing has been grooved, the backing is burnished into the groove. The backing is then burnished close to the facing, the extending end bent over the incisal edge of the facing and the tooth pins bent outward to hold the backing in place. The pin is then put through the floor and it is placed on the model and waxed for soldering. (Fig. 575.) It is invested as shown in Fig. 621. If a crown has been removed, or the natural crown has broken off, the temporary crown can be made at the chair. The top of the root is ground flat and the canal is opened up for the reception of the pin. The facing is grounded to the root the same as to the model. The backing is made as already described, placed over the pin on the root and the floor burnished to the face of the root and the whole waxed together with sticky wax, removed from the mouth and soldered.

A temporary bridge on practically the same order can be made quickly on the model. Let us say certain teeth are badly diseased and it is necessary to remove them, for example, the four incisors. The cuspids are first opened up and the canals filled. An impression is taken and also a rough bite and a model prepared. Facings for the six anterior teeth are selected. The cuspids on the model are cut off, prepared the same as for a single crown described above and opened up for the posts.

The incisors are now cut off just below the gum line. A bar extending across and the posts can be made continuous, measuring the distance between the openings in the stumps and bending the wire so that it will enter the canals freely. (Fig. 572.)

The facings are now ground in and a plaster wall built on the labial side the same as in Figs. 570 and 571. The facings are next backed with 36-gauge pure gold, the cuspids having backing and floor continuous, as in Figs. 574 and 575, while the incisors have the backing extending a little beyond the incisal and gingival edges and turned back over these edges. (Fig. 576.) The backed facings are now replaced on the model (Fig. 577) and all waxed together, removed, invested, soldered and finished.

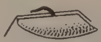

FIG. 576

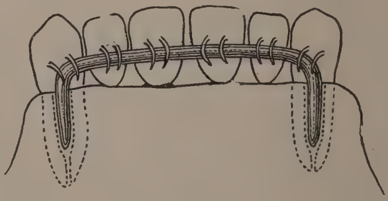

FIG. 577

The patient is then called in and the incisors are removed. The crowns of the cuspids are cut off, the labial side just flush with the gum and the palatal side a little less than $\frac{1}{16}$ of an inch above the gum. The canals are now enlarged and paralleled with root reamers and the bridge tried in. It may be that the pins do not follow exactly the direction of the canals in the roots, but the pins can be easily bent to follow them and it takes but a short time to adjust the bridge. It can be set with temporary stopping or base-plate gutta-percha. It is then articulated so that there is no undue strain on the roots, and the patient dismissed.

A bridge made in this manner and placed in the mouth immediately following the extraction of the roots so that no one outside of the office sees the patient without teeth, gives the utmost satisfaction and does much to win the respect and confidence of the patient.

The bridge can be worn until the gums are in such condition that a permanent bridge can be inserted. If the roots are not large, it is a safe procedure to place a small band around them before setting the bridge. In fact, it is a good practice to use this band in practically all cases as a precautionary measure.

Where an all-porcelain crown is used, the work can be done on the model or in the mouth. The crown is ground to fit the model and the pin is prepared to go into the canal extending up into the hole in the base of the crown. They should now be finished in the mouth. The root canals are opened up, the pins are placed in them and the crowns are placed over them. It may be that the pin may have to be bent a little as it leaves the root in order to set the crown in the proper position, or it may have to be shortened a little, After it has been properly adjusted, the hole in the base, and the pin are dried, and the pin cemented in the crown.

The cement is mixed fairly stiff, just so it can be worked into the hole in the base of the crown, and the pin is pressed into the crown. While the cement is still a little plastic, the crown is placed on the root and pressed into its proper position, the cement will give a little while it is slightly soft; it is now held for a minute or two until the cement is stiff enough so that the pin will not change position, when it is removed and put in a warm place and the cement will harden very quickly.

A crown like this can be made in the mouth in a few minutes, facing the root and grinding the crown to it. It can be set with base-plate gutta-percha, or if it has to be removed every day or two for work or treatment, it can be set with temporary stopping.

Where the natural crowns of the teeth have to be removed, they should be cut off with a very thin disk when possible, very close to the gum on the labial side and just a little above the gum on the lingual side. The pulp-chamber is opened up and the canal is enlarged.

A pin is prepared and the crown is adjusted exactly the same as a porcelain crown. This makes a most satisfactory temporary crown and the natural crown can be used even when quite badly decayed, the cavity excavated and filled when the pin is cemented in.

PERMANENT CROWNS.

In all permanent crowns, whether used as single crowns or serving as abutments for bridgework, the root should be banded so as to obviate any liability of fracture owing to the extra strain to which the root may be subjected.

The first requisite of this band is that it shall fit absolutely, not approximately. Faults in this direction are the most common and those to be most guarded against. The second requisite is that these bands shall not be irritating to the vital parts, and yet shall offer a perfect protection against the ingress of pathogenic organisms or their products to the parts we design to protect. This implies that the band shall not impinge on the pericementum, nor must it have any roughened edge or surface to irritate the overlying gum. It should extend to such depth beneath the gum margin that the gingival margin shall form a barrier, not the wall of a pocket. The band should grasp, but not irritate; $\frac{1}{16}$ inch or a trifle over in depth will be sufficient in the majority of cases.

Constructing a Built-up Contoured Gold Crown with Solid Gold Cusps.—*Taking the Measurement of the Root.*—The measurement of the root should be taken straight across and as nearly at a right-angle with the sides as possible. It is very rarely that this measurement should actually follow the gum line. Where there has been a recession of the gum on one or more sides of the tooth, if the wire with which the measurement is taken is carried down to these points all around, it will be found that the band, when it is made, will be too large to fit the root.

As will be seen in the illustration of a lower molar where the tissues are high at the back, but show a considerable recession on the mesial side of the tooth (Fig. 578), if the measurement is taken following the line of the gum from *a* to *b*, when it is brought up so that it extends straight across following the line *a* to *c*, it will be much larger than it should be. The wire should be forced as far under the gum distally as possible and then brought straight across to the point *d*. Then, too, in Fig. 579, showing an upper molar with considerable recession of the tissues bucally and lingually, it can readily be seen that, if the measurement follows the gum line from *a* to *b*, when it is straightened out it will extend from *c* to *d*, with the result that a band made to this measurement would be much too large.

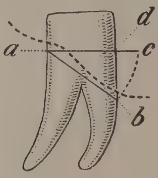

Fig. 578

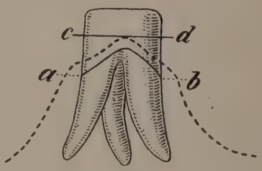

Fig. 579

FULL GOLD CROWNS.

In the consideration of full gold crowns, the built-up, solid-cusp crown is unquestionably better than any other and as it is probably most quickly and easily made, its construction will be described. The measurement of the root is taken; the band is made of No. 30 coin gold.

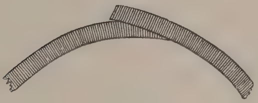

Fig. 580

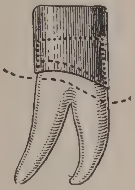

Fig. 581

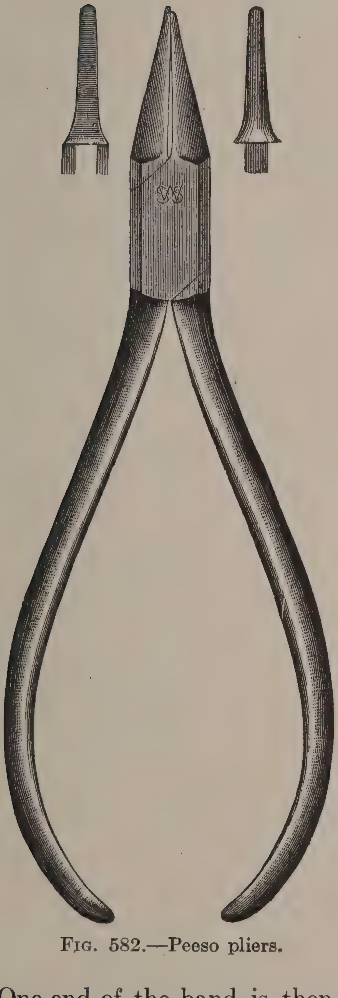

Fig. 582.—Peeso pliers.

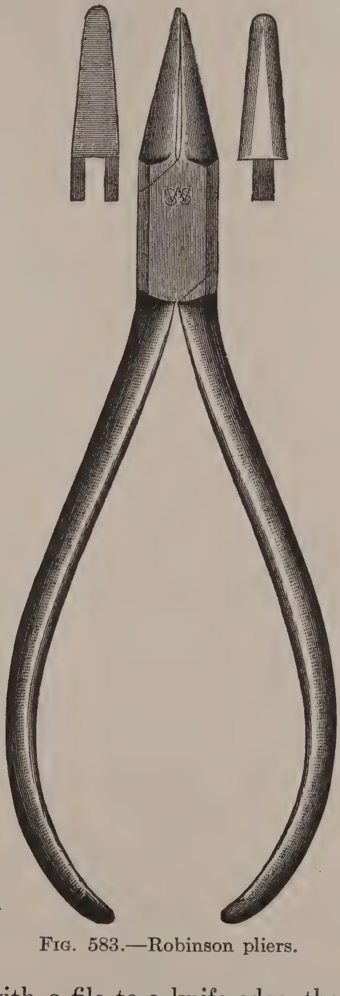

Fig. 583.—Robinson pliers.

One end of the band is then beveled with a file to a knife edge, the ends brought in contact, bringing the beveled end under the other

(Fig. 580), and sweated or soldered together. It is then given the approximate shape of the stump, and roughly festooned or trimmed to follow the gum line. (Fig. 581.)

The shaping of the bands is best done with the collar pliers shown in Figs. 582 and 583. The beaks of the pliers in Fig. 582 are very narrow, one having a flat face, the other being rounded and slightly shorter than the other. The beaks of the pliers shown in Fig. 583 are made on the same plan, but are larger and heavier.

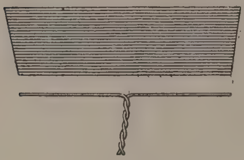
Fig. 584

Where there is much contour to restore, the gold plate for the band is cut on a bevel, measuring from the gingival edge and flaring outward toward the occlusal edge. (Fig. 584.) The band is now fitted to the root, cutting and filing the edge and following the gum line carefully and extending about $\frac{1}{16}$ inch below it. It is then cut down a little short of the occlusion, replaced on the root and the impression and bite taken. The impression should preferably be taken in plaster of a very fine grade. Modeling composition or wax should rarely be used. If there are dove-tailed spaces or undercuts to be secured, modeling composition will not give an accurate impression, but whatever the position or condition of the teeth may be, a cast made from a carefully taken plaster impression will be an exact reproduction of the parts.

The bite should also be taken in plaster, and this may be done simultaneously with the taking of the impression. The advantage of taking the bite and impression at the same time in plaster is the absolute accuracy of the relation of the upper and lower teeth which is thus secured. Where the bite is taken in this way, it is possible to make and articulate a crown or a bridge so perfectly that when it comes from the model, it is finished and will not have to be touched to correct the occlusion when it is placed in the mouth. When a tray is used for the plaster impression and the bite is taken separately in wax, the occlusion of the piece will invariably have to be readjusted when it is placed in the mouth. It is then sent back to the laboratory for a second finishing and polishing, for if it is finished in the mouth, the polishing can never be properly done. The cusps and fissures, which are necessary for perfect mastication, are partly or wholly obliterated and the usefulness and beauty of the piece are destroyed or at least impaired.

As the impression and bite are conjointly taken in a similar manner for a single crown or for a small bridge, the description of one will answer for both. Suppose it to be a bridge case; the abutment caps having been made, they are placed in position on the teeth or roots and the patient instructed in opening and closing the mouth so that the correct occlusion may be secured. Every dentist knows how difficult, and at times almost impossible, it is to get patients to close the mouth properly. The mandible is protruded or thrown to one side or the other as they bite into the plaster or wax. If, while the mouth is open, the patient is told to place the tip of the tongue far back on the soft palate, and to keep it there while the mouth is being closed, it will be difficult for the patient to give the wrong bite, as when the jaw is thrust forward or to one side, the tongue must move with it. In any but large cases, a little salt or potassium sulphate should be used to hasten the setting of the plaster, but in very large cases, nothing should be used for this purpose, as the plaster is likely to set before it can be properly distributed. The plaster should be thoroughly mixed, and when it is just stiff enough so that it will not fall from the spatula when the latter is inverted or turned edgewise, it is ready for the mouth. It is carried in on the spatula and the abutment teeth should be well covered; a few of the adjoining teeth are included in the impression and the plaster is built up thickly in the space intervening between the abutments. The surfaces of the occluding teeth in the opposite jaw are also covered, and the patient is instructed to close the mouth, to bring the teeth tightly together, and cautioned not to move the jaws until the plaster is well set. The teeth which are not included in the impression are carefully examined to see that the jaws are in their correct occlusal relation. With a wet spatula the plaster may be smoothed and pressed around the teeth and gums on the labial and buccal sides.

The patient is requested to separate the jaws slowly and carefully when the impression is hardened, and it is removed, coming away generally in a more or less broken condition; the broken parts are easily united and fastened together with adhesive wax. The abutment caps are then removed, if they have not come away with the plaster, and placed in position in the impression. Their inner surfaces are to be given a coating of melted pink wax, enough being used to obliterate any undercuts. (Fig. 585.) The impression is then varnished and the cast run.

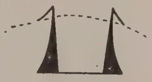
FIG. 585

In all extensive cases an anatomical articulator should be used, but for many small bridges and for single crowns, a plaster articulator may be used. In making the cast from a bite of this kind, the lower half of the impression is run first. The reason for this is, that by having a regular system for running casts, the operator always knows just how to separate them safely. When the sides of the casts are trimmed, the grooves in their posterior extensions (to be referred to presently) will enable him to distinguish at once the upper from the lower side and to know just how to cut without danger of injuring the cast. The casts should be well trimmed and should be no larger than is necessary.

Working casts should always be made of the hardest plaster obtainable. Hard plaster is always coarse and can be distinguished by rubbing a small amount of it between the thumb and finger. It is always slow setting and nothing should be used to hasten this, as rapidity of setting is gained at the expense of hardness. It should be mixed with cold water and stirred only just enough to secure a homogeneous mass.

Much stirring has the same effect as the use of salt or warm water, making the plaster set more quickly but reducing its hardness.

For a separating medium, sandarac varnish gives as good results as anything that may be used. It is first colored with a little carmine, or a little of the crayon of an indelible or of a copying pencil scraped into the varnish. Only a little of the crayon is needed to impart a pinkish or purplish tint. The impression should be slightly moist for varnishing, since if it is dry, the sandarac will soak into the plaster and will not give a glazed surface; while if it is too wet, the varnish will not adhere sufficiently but will scale off. If the impression has dried out, it should be dipped in water and then laid on blotting or bibulous paper for a few minutes before varnishing. It will make the separation from the cast easier if the surface of the impression is dusted with talcum powder, the excess of which should be blown out with a chip-blower. Oil should not be used as a separator, as it has a tendency to make the surface of the cast soft. A soap solution makes an excellent separating medium. The impression is coated thoroughly with the solution, using a soft brush to apply it, after which it is well rinsed in clear water. If this is not done and any of the suds are left in the impression, the surface of the cast will be covered with holes and bubbles and will be soft.

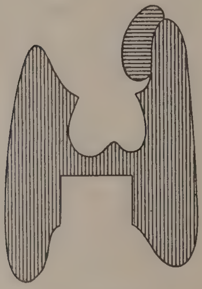

Fig. 586

The plaster for the cast should be mixed a little stiffer than for taking impressions. The half of the impression which is to be poured first, is filled with water, the most of which is shaken out, leaving a little in the bottom. A very small quantity of plaster is now placed on the edge of the impression and worked down into it with a jolting or jarring motion (Fig. 586), adding a little at a time until it is filled. A small camel's-hair brush may be used to work the plaster in, but will give no better results than the method described, if due care is used to avoid the confining of air.

After the impression has been filled, the remaining plaster is scraped from the bowl upon a glass slab and the filled impression inverted upon this. The plaster should extend an inch or more beyond the distal side or end of the impression and a separating plate (Fig. 587) pressed into it, the ridged side down. (Fig. 588.) This is allowed to remain for a few minutes until the plaster has set, when it is removed. The cast is trimmed and the surface produced by contact with the separating plate is varnished (Fig. 589), and after allowing it to dry for a few minutes, the upper half is run in the same manner as the lower, covering the varnished extension with plaster and pouring the surplus on the slab, the upper half being pressed into it. After allowing it to harden for a few minutes, it is removed from the slab and trimmed. (Fig. 590.) In the absence of the separating plates, the plaster may be smoothed with a spatula, and after it has become hard, grooves or

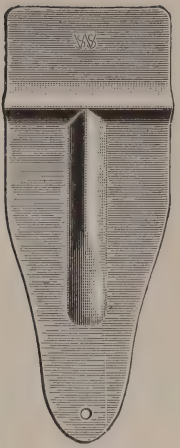

Fig. 587

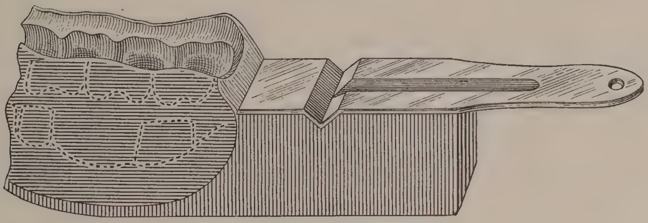

Fig. 588

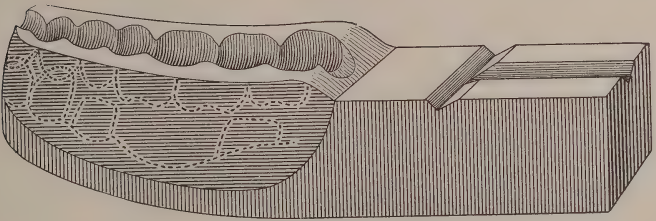

Fig. 589

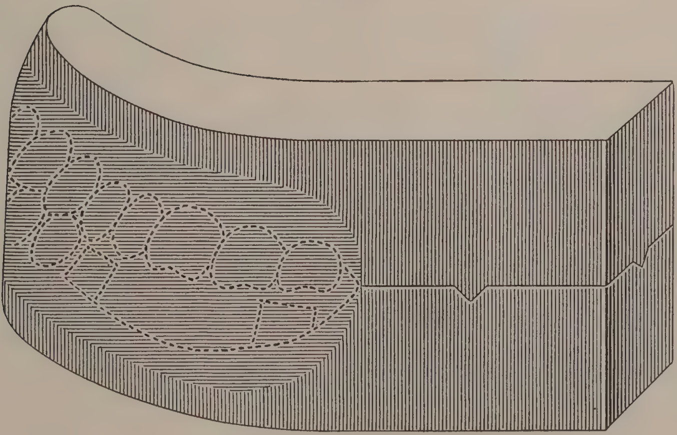

Fig. 590

notches may be cut in it with a knife, after which it is varnished as before. In separating, the impression is carefully cut away from the sides, until the purplish tint from the varnish shows that the cast is near, and the teeth are uncovered as far as possible. When the impression is nearly all cut away, the point of a knife is introduced between the articulating surfaces and by a little careful prying, the halves are separated, after which the remainder of the impression is easily removed. The casts are then trimmed and smoothed and if they are rubbed with talcum powder, it will give them a beautiful polished surface.

If the tooth or root has been properly prepared, the band may be made and the crown or bridge completed without the band having been first fitted in the mouth, the whole of the work being done on the prepared model. In preparing the model for this procedure, it is first dried thoroughly and then trimmed, cutting down on a line with the sides of the tooth to nearly $\frac{1}{16}$ inch below and parallel to the cervical margin. (Fig. 591.) After the trimming, it is soaked with thin sandarac varnish and again dried. This will make the model hard enough to withstand the wear incident to fitting the bands. The sandarac varnish as purchased at the dental depots, diluted one-half with alcohol, is suitable for this purpose.

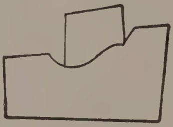

FIG. 591

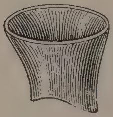

FIG. 592

If the band has been fitted to the tooth, after the articulating cast has been obtained, it is removed by grasping it with a pair of slightly heated pliers, which softens the wax at its inner surface; the wax is burned off and the band cleansed in dilute sulphuric acid. The contour is made by stretching the band toward the occlusal portion. (Fig. 592.) This may be done on the beak-iron of an anvil with a small hammer, or with a pair of stretching pliers designed especially for this purpose. (Fig. 593.) This gives the band a decided flare and if it remained like this, there would be only a hair line of contact between the crown and an adjoining tooth. A broad contact is desirable and this is obtained by annealing and straightening up the upper third of the band. This is done with the Robinson pliers, placing the rounded beak inside and pressing the band inward until the sides are parallel. (Fig. 594.) It is then annealed and given the normal shape with the fingers and collar pliers. The band is placed on the model and the buccal and lingual sides grasped between the thumb and finger and pressed in until they are on a line with the other teeth. The pliers are then used to make the buccal and palatal or lingual fissures and to remove any little irregularities which may exist in the band. It is now cut short enough to allow the placing of a thick solid cusp and the top edge filed perfectly flat. If from a plate or buttons a suitable cusp can be selected, a matrix of very thin pure gold is made from it by swaging into a fusible

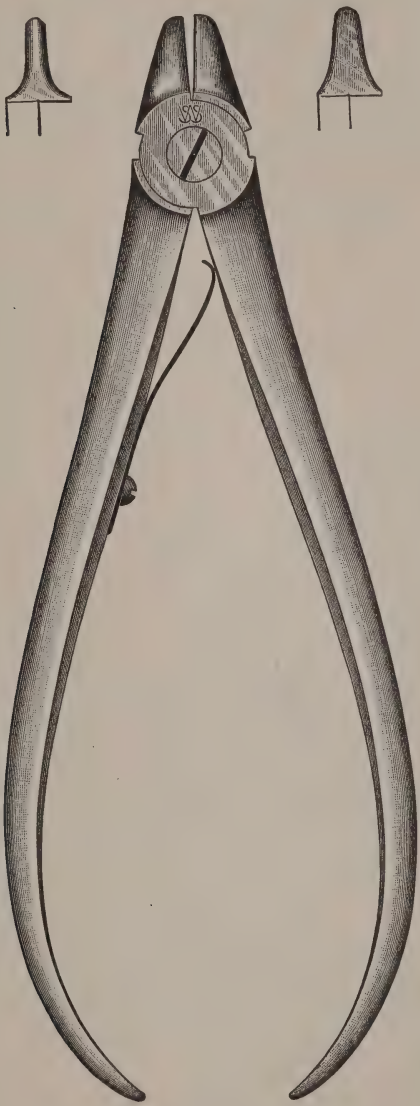

FIG. 593

metal die, and this, after it has been cleansed in nitric acid, is filled with coin gold (Fig. 595) and the under surface filed flat (Fig. 596) so that there will be perfect contact between its periphery and the band. These are then wired together with iron binding wire, the wire being twisted at the gingival end of the band, and a little borax or soldering fluid placed around the inside at the point of contact with the cusp. A couple of pieces of solder are now placed on the inside next to the band and the crown held over the flame of a Bunsen burner by the twisted wire until the solder has flowed all around. (Fig. 597.) The wire is then removed, the crown cleansed in acid, any overhanging edges of the cusp ground away, and the crown finished and polished.

FIG. 594

In the event of a suitable cusp not being found, the top of the band may be filled with soft plaster or modeling composition and the occluding teeth, having been previously covered with oil or talcum powder, pressed into it and moved in various directions. After the plaster or composition has hardened, the cusp is carved to represent as far as possible a typical cusp for the given tooth, and a die of fusible metal made and solid cusp secured as already described.

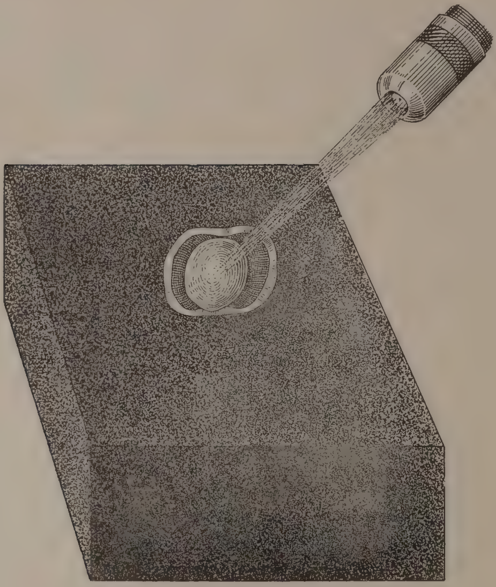
FIG. 595

FIG. 596

A much better way of making these crowns is the use no solder at all, but to sweat the joints throughout. If solder is used, it is sure to discolor in time and dark lines will indicate the several joints. The sweating of the band is done with the blowpipe or with a brush flame or the flame of a Bunsen burner. In using the blowpipe the band is placed on a charcoal block with the seam to be united uppermost, covered with a little borax or soldering fluid. The flame used is the inner blue point of the blowpipe flame and should be from 1 inch to 1¼ inches in length. The whole of the band is brought to a very bright red heat and the point of the blue flame gently passed over the joint, (Fig. 598) melting the gold together at that point and at no other. In using the brush flame, the band is placed on the charcoal as above and a large brush flame is applied, holding it on the band until the gold begins

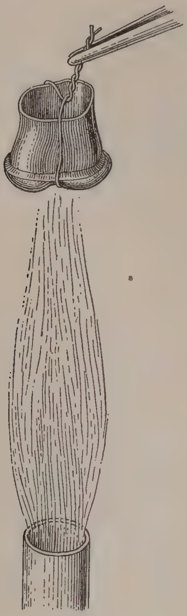

Fig. 597

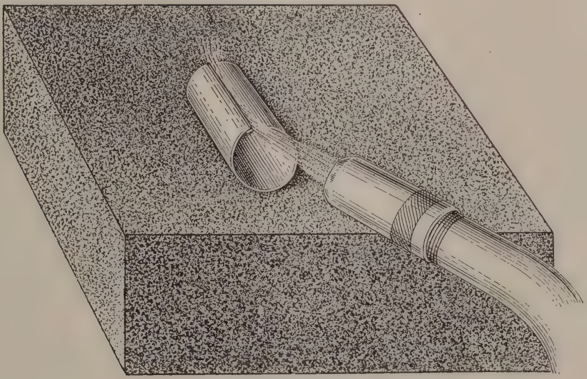

Fig. 598

to fuse, when it is quickly removed. This makes a stronger union than can be made with any solder. The higher the carat of the solder used, the stronger is the union and where none is used, the band will be practically seamless and as strong, or stronger at that point than at any other. The band is then festooned, contoured, and filed flat as already described. The cusp is made and wired to the band as in the soldered crown. It is then fluxed and held by the twisted wire with a pair of light pliers, cusp down over a Bunsen flame well toward the top, so that the thick cusp will be heated first until it is nearly at the melting point. (Fig. 597.) The crown is then lowered a little in the flame and held until the gold begins to melt and unite the band with the cusp (Fig. 599), after which it is cleansed in acid and the crown finished and polished.

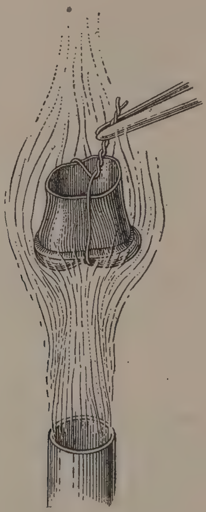

Fig. 599

JACKET CROWNS.

There are times when it is desirable to preserve the pulp of a tooth anterior to the molars where through accident or decay the tooth is too far broken down to be restored with inlays or fillings. As in the six or eight anterior teeth the placing of a gold crown is out of the question, it becomes necessary to make a shell which will cover the tooth, and protect the pulp, to which may be attached a porcelain facing. This makes a very good crown and can be made by those who have not the facilities for making porcelain crowns, or those who live long distances from laboratories where they could be made. The face of the tooth is ground away as much as possible without endangering the life of the pulp, cutting well under the gum as in Fig. 600. The sides and palatal portions of the tooth have their enamel removed, so that the band will hug the root tightly under the gum. The band is then made and fitted to the root and cut out on the labial side flush with the tooth. (Fig. 601.) The palatal side of the band is then pressed in close to the root and the mesial and distal sides of the band spread out nearly or quite to the width of the facing which is to be used, and a floor of coin gold sweated or soldered to it. (Fig. 602.) A thin facing is then ground so as to leave a little space between it and the cap, touching the latter only at the tip. The facing is now backed with thin platinum, crown metal or pure gold, letting it extend about $\frac{1}{16}$ inch over the incisal edge. It is then waxed to the cap, invested and soldered, flowing the solder between the facing and the cap and if necessary over the palatal portion of the band. (Fig. 603.)

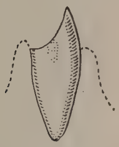
Fig. 600

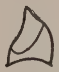
Fig. 601

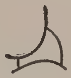
Fig. 602

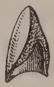
Fig. 603

Another method of making this crown is to carry the band to the full height of the tooth, to contour it, and cut it out on the face to the depth of the facing. (Fig. 604.) The facing is then ground to fit the edge of the cap so formed and a backing of coin gold fitted carefully to it. (Fig. 605.) This is then adjusted to the cap, waxed, the facing removed and the backing grasped in a light pair of pliers and soldered to the cap with 22-carat solder. The surplus backing is then trimmed away (Fig. 606) and the facing put in place, the pins waxed on the inside of the cap, and the crown invested. The crown is invested face down and

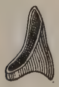
Fig. 604

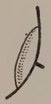
Fig. 605

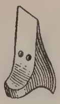
Fig. 606

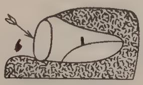
Fig. 607

covered but lightly, leaving the opening fully exposed as in Fig. 607. It is thoroughly dried out and flux placed on and around the pins. A piece of 18- or 20-carat solder is then placed over the pins, the whole brought to a bright red heat, and with the fine blue point of the blowpipe-flame thrown on the inside, the solder is melted, uniting the facing to the cap. It is then finished and polished. (Fig. 608.)

In the making of a porcelain-faced crown for a bicuspid having a vital pulp, the tooth is prepared in the same way as in the anterior teeth, cutting it well out on the buccal side and grinding away the inner cusp. (Fig. 609.) The band is then made as for a full gold crown, and cut even with the cusp at the top and enough on the buccal side to allow for the facing. (Fig. 610.) The facing is then ground to fit the edges of the cap (Fig. 611) and a backing of coin gold fitted to it. (Fig. 612.) The backing being fitted to the facing, it is placed in position on the cap and waxed and soldered with 22-carat solder. The backing is then cut off even with the rest of the band and filed flat. (Fig. 613.) The tip of the facing is then ground on a bevel at an angle of about 45 degrees, the lower edge of the bevel being on a line with the top of the cap. (Fig. 614.) A cusp is then selected, the under surface filed flat and the buccal side beveled to meet the bevel of the facing.

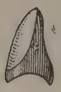
Fig. 608

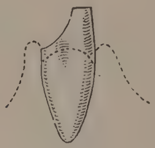
Fig. 609

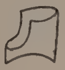
Fig. 610

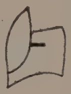
Fig. 611

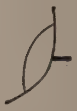
Fig. 612

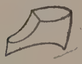
Fig. 613

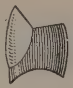
Fig. 614

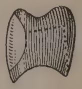
Fig. 615

The cusp is then wired to the cap and soldered with 22-carat solder, the facing having first been removed. The cap is then cleansed in acid and the facing replaced in position and waxed. It is then invested and soldered from the inside and finished as already described. (Fig. 615.)

BAND AND PIN CROWNS.

While a pin and plate crown or any of the manufactured crowns are especially adapted for temporary work, where permanent operations are desired, the root should always be banded so as to reduce to a minimum the possibility of a fracture. It is always best to be on the safe side in the beginning and to treat a root so that there is no possibility, or at least a very remote one, of trouble of this kind. The Richmond crown was one of the earliest in which the pin and band were combined, and for many years was one of the most popular permanent crowns used in the front of the mouth. It is still used a great deal, but more especially as an anchorage for bridgework.

The root having been properly prepared as already described, the band is fitted to it, after which it is removed and the root faced to the depth desired. It is then replaced (Fig. 616) and marked around its inside and cut off flush with the top of the root, which should be about $\frac{1}{32}$ inch under the gum on the labial side and about $\frac{1}{16}$ inch or a little less above it on the palatal. (Fig. 617.) With a fine file it is then filed perfectly even and a floor of No. 30 coin gold is sweated or soldered to the band. (Fig. 618.) It is now replaced on the root and a hole made in the floor over the enlarged root canal for the reception of the pin, which latter is preferably made of platinized gold. This is placed in position and fastened with adhesive wax (Fig. 619), removed, invested and soldered. It is then put back on the root and the impression and articulation taken, after which the cast is prepared in the manner already described. After separating, the cap is removed from the cast with a pair of heated pliers and the floor on the labial side of the pin is ground or filed perfectly flat. It is then replaced on the model, and a suitable facing selected and ground to fit the floor of the cap. A backing of thin platinum or 36-gauge pure gold is then made, extending from the floor of the cap to about $\frac{1}{16}$ inch above the tip (Fig. 620). The facing is then waxed in place with adhesive wax, and when this is nearly hard, the facing is pressed tightly against the backing to bring them into close contact. The crown is now removed from the model, invested and soldered. The investment should be made to cover the band partly and take in the backing which extends beyond the cutting edge, thus holding it down and preventing it from drawing away from the facing in soldering. (Fig. 621.) When the investment has cooled, the crown is removed, cleansed in acid and finished. (Fig. 622.)

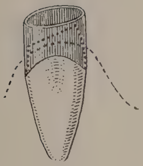
FIG. 616

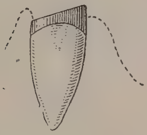
FIG. 617

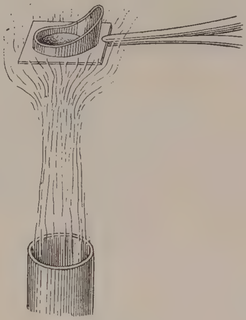
FIG. 618

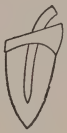
FIG. 619

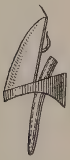
FIG. 620

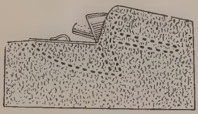
FIG. 621

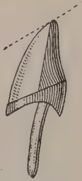
FIG. 622

A favorite and easy way of setting in the facing, is to grind it away so that only the tip of it touches the floor of the cap at is outer edge, and then to let the backing extend all the way to the end of the facing, and fill it in with solder. (Fig. 623.) The principal objection to this method, is that in many cases the gold can be seen from the front or side of the mouth, or there is a dark shadow between the teeth toward the gingival portion of the crown, which renders it unsightly and unnatural in appearance.

In the making of the so-called Downey porcelain crown, where a facing is used, the band and cap are made in the same way as for a Richmond, with the exception that iridio-platinum plate, No. 32 gauge, is used instead of gold and the band is cut lower on the palatal side. The pin is also of iridio-platinum. For these crowns it is well to have only the tip of the facings touch the outer edge of the cap, as this permits the porcelain body to be worked under the facing better than when it is close to the floor. (Fig. 623.)

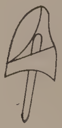

Fig. 623

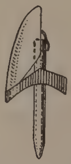

Fig. 624

The facing may be grooved out between the pins to permit the post setting well into the facing (Fig. 625), allowing plenty of room on the palatal side for the porcelain body. The two pins may be notched slightly with the edge of a small half-round file (Fig. 626) toward the incisal end to allow them to be bent flat against the facing and brought into contact with the sides of the post. (Fig. 624.) They should not be bent out and around the post, as this would frequently carry them so far lingually as to show through the porcelain, and consequently weaken the crowns.

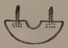

Fig. 625

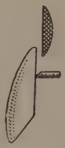

Fig. 626

After the pins are bent in contact with the sides of the post, they are waxed firmly with hard sticky wax. A small amount of wax should be flowed around the labial edge of the band between it and the facing to prevent any of the investment material from working in between the facing of the cap.

In investing this for soldering the pins to the post, a small amount of investment is placed on the slab and smoothed off perfectly flat, leaving it from about $\frac{3}{8}$ to $\frac{1}{2}$ inch in thickness. The crown is then laid face down on the investment and pressed lightly until it is imbedded even, or flush, with the lingual side of the facing. A little of the investment is then placed over the end of the pin to hold it in position. (Fig. 627.)

No investment should be placed inside of the cap. This should be kept perfectly clear, the bulk of the pin and the cap being exposed to the flame. If the cap is filled with investment material, and the post and cap thoroughly covered, as in the illustration (Fig. 628), it will require a greater length of time, and much more heat to unite the pins to the post, as there would then be such a large mass of investment to heat up. The investment taking the heat from the post, would make it very difficult to get it hot enough to solder the pins of the facing to it with pure gold. On the other hand, if the cap and the larger part of the post are left exposed, as soon as the investment is heated up to a red heat, by throwing the flame on the metal parts, the pure gold will quickly flow in between the pins and the post.

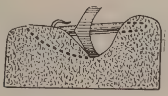
FIG. 627

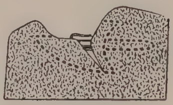
FIG. 628

The flame of the blowpipe should never be thrown on the metal parts until after the investment and facing are thoroughly heated to a bright red heat, otherwise the facing will be broken, owing to the sudden expansion of the platinum pins. After it has been soldered, it is cleansed in acid and is ready for the application of the porcelain body.

THE CASTING PROCESS AND ITS AVAILABILITY IN CROWN WORK.

The introduction of this method has opened up a large field in this branch of prosthesis, but it must be employed with a full recognition of its limitations. Cast gold is not as strong as rolled gold, and a bridge of the former is not so strong as one built up and soldered. The shrinkage of the metal in cooling must also be taken into account or failure on that score is sure to result.

The metal used for this work should be of high carat and of as great tensile strength and rigidity as possible. It should not be overheated. Coin gold seems to be well adapted for this purpose, as it possesses the qualities above mentioned and gives a good sharp casting.

All-porcelain Crown with Cast Base.—This, being one of the simplest and easiest crowns to make, will be first considered. The root for a crown of this kind requires little preparation, as compared with one for a Richmond or other banded crown. The face of the root may be irregular from decay or fracture, or it may have been ground down to meet the demands of the case. In any event, it should be cut well beneath the gum line on the labial side, and on the lingual side enough to suit the requirements of occlusion. The lingual side should be beveled so that the base will overlap, thus giving additional support to the crown, and at the same time, serving to strengthen the root and overcome the liability of fracture. (Fig. 629.) The crown is then ground to conform to the size and shape of the root, and to touch it only at the labial side, leaving plenty of room between the balance of the face of the root and the crown to allow for a heavy base, as in Fig. 630.

The dowel, or pin, which is preferably made of plantinized gold wire, is then adjusted and should be of sufficient length to go nearly or quite to the bottom of the hole in the base of the crown and into the root to a depth at least equal to the length of the crown. (Fig. 630.) It is well to flow a little sticky wax around the post, between the base of the crown and the face of the root, at point *a* in Fig. 630, as the wax, of which the base is to be made, will adhere to the post better than it would otherwise.

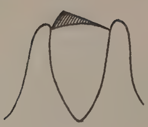

Fig. 629

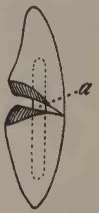

Fig. 630

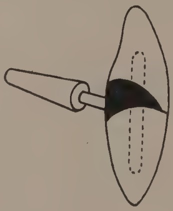

Fig. 631

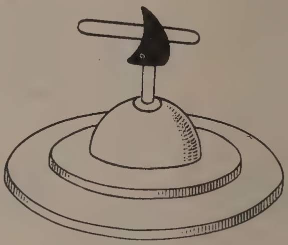

Fig. 632

The base of the crown is then lightly oiled, or coated very thinly with cocoa butter to prevent the wax from sticking, and the base wax, which should be a little softer and tougher than the ordinary inlay wax, is softened and pressed around the pin at the base of the crown, which is then forced on the root and carefully adjusted in position. After the wax has been chilled, the surplus is carefully trimmed away until it is perfectly smooth and flush with the sides of the crown and root. (Fig. 631.) The crown, together with the pin, is then removed from the root and the sprue wire attached, as in Fig. 631, by heating it just enough to imbed it slightly in the wax. It may be more firmly fixed by flowing a very small amount of wax around it at the point of entrance, after which the crown is removed.

The sprue wire is now placed in the base of the flask (Fig. 632), and the crown base is invested in the same manner as an inlay, painting the investment very carefully so that there may be no air bubbles, which would be reproduced in gold in the casting and interfere with the fit of the base. After casting, it is cleaned and polished and adjusted to the crown and root. The base is first cemented to the crown, and after the cement has thoroughly hardened it is cemented in the mouth.

This makes a lasting crown when used singly, but it is not to be used for a bridge, as all bridge abutments should be banded.

Banded Crowns.—The caps for these crowns can be made in the same way as for a Richmond crown, being carried well beneath the gum labially. The impression is taken and the cast prepared in the usual way.

The crown is ground in the same manner as already described in treating of the crown with the cast base, being beveled lingually and mesially and distally about half way to the labial face. (Fig. 633.) This allows a sort of socket for the crown to sit in and, at the same time, insures the correct position of the crown on the base.

The base of the crown is lubricated, so that the wax will not stick to it, and the wax is flowed in between the crown and the cap, until it is well filled, after which it is carved flush with the crown and the band and the sprue wire attached, as in Fig. 631. The crown is now removed, leaving a wax base attached to the cap. It is then set in the flask base and invested and cast in the usual manner. The base should be polished with the crown in position, after which the crown is cemented to the base and kept under pressure until the cement has hardened. It is then ready for the mouth.

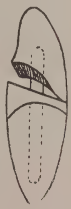

FIG. 633

This method of procedure may be followed in making any crown of this type from molars to incisors.

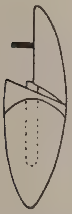

FIG. 634

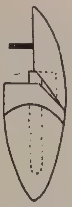

FIG. 635

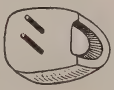

FIG. 636

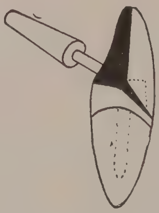

FIG. 637

Crowns with Porcelain Facings.—In crowns of the Richmond type, where a porcelain facing is used, the cap and pin are made and fitted to the root, and the facing ground to place, sloping it slightly more than the floor, so as to allow the gold to flow under the facing. (Fig. 634.) If there has been much recession of the gum, so that the band has to be sloped greatly labially (Fig. 635), it is well to grind a step in the bottom of the facing, so that there may be a good base for it to rest on, thus rendering it less liable to be forced down the incline and fractured. (Fig. 636.) The facing is then lubricated on the lingual side, and held in place with a little sticky wax on the labial side, or a light wall of plaster or modeling composition, and the lingual side is built up with hard inlay wax and carved and smoothed carefully. (Fig. 637.)

It should be remembered that the better it is finished in the wax, the easier it will be to finish the completed crown. The sprue wire is attached, as shown in Fig. 637, the facing carefully removed and small pins of graphite inserted in the holes left by the tooth pins, leaving them long so as to be gripped in the investment. (Fig. 638.) Another way is to enlarge the pin holes in the wax after removing the facings and dovetail them on the inside, as in Fig. 639. This can be easily done with a small coarse bur. It is then invested, care being taken to fill the pin holes, if they have been enlarged, and cast. After the casting has been made, the graphite pins are removed, the sides of the holes roughened, and the piece cleansed and polished. The tooth pins are then lightly grooved or roughened and the facing cemented.

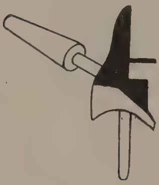

Fig. 638

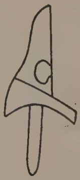

Fig. 639

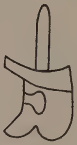

Fig. 640

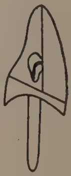

Fig. 641

If the holes were enlarged and dovetailed, the pins may be flattened a little at the end, and then bent at right-angles, as shown in Fig. 641, and cemented in place. Fig. 640 shows a bicuspid prepared for a facing.

Anterior teeth, such as the centrals or laterals, are frequently found which have been broken off, as from a blow, the fracture on the lingual side extending far above the gum line (Fig. 642). They should be treated in practically the same way as the molars in the preceding case. The stump standing out of the gum is trimmed very carefully so that the sides are parallel. In this case, much greater care should be exercised to have these sides parallel than where the whole stump is standing and the root has simply to be crowned. The canal is enlarged and a post fitted into it, extending well out of the stump.

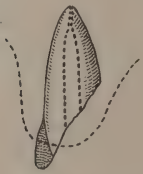

Fig. 642

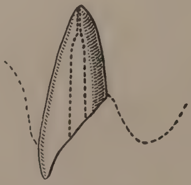

Fig. 643

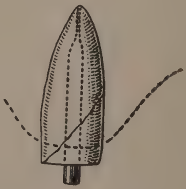

Fig. 644

It is understood that the tissues should be first pressed away (Fig. 643.) The fractured part is then restored with cement, building it up around the post to about the same height as the part of the stump left standing out of the gum, care being taken to trim close to the margin of the root and make the sides of the cement filling parallel to the standing stump. (Fig. 644.)

If we have the part of the root which has been broken off, it can be put back in position, after removing any other enamel which may adhere to it, instead of replacing it with cement. The impression is taken with this in place. The broken piece of the root or the cement is then removed together with the post, and placed in the impression and a model made in the manner already described. The model is then trimmed carefully, well below the gum margin labially, and below the line of fracture lingually (Fig. 645). The cement and post are now removed and the labial side of the stump cut off enough so that the band will be hidden by the gum (Fig. 646). On this model the band is fitted, festooning it carefully so that it will come below the line of fracture lingually, and well under the gum on the labial side. (Fig. 647.)

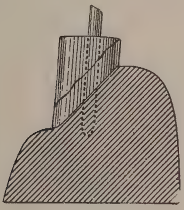
FIG. 645

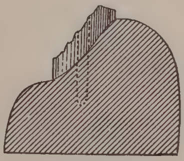
FIG. 646

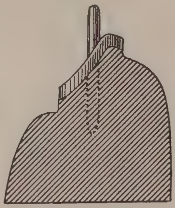
FIG. 647

If, for this case, a Richmond crown, with a facing and a gold back, or an all-porcelain crown with a soldered or a cast base, is to be made, the upper edge of the band may be cut flush with the edges of the stump lingually, and well under the gum labially and a floor soldered or sweated to it. The post is next fitted and waxed in position and soldered or sweated to it. The post is next fitted and waxed in position and soldered to the floor of the cap (Fig. 647). This completed cap is then placed on the root in the mouth, an impression and articulation taken, the model prepared and the crown made and finished in the usual manner, carrying the solder down to the edge of the band on the lingual side. (Fig. 648.)

Where an all-porcelain crown is to be used, it is ground to fit the floor of the cap on the labial side, but should clear it well on the lingual or palatal side, and the mesial, distal and palatal sides are beveled slightly. A pin of platinized gold is placed in the hole in the base of the crown, which has previously been lubricated with a little oil or cacao butter, or if it is desired to cast the pin with the base, wax is forced into the hole and the crown held in place and hot wax flowed in between the crown and the cap and over the beveled edges of the cap. It is then carved, the sprue former attached to the lingual side, the crown removed and the base flasked and cast to the cap.

If desired, after the crown has been ground to the cap and beveled, a base of pure gold can be carefully burnished and fitted to it, a platinized gold pin passed through it into the hole in the crown, waxed, removed, invested and the pin soldered to the base with a little coin gold. After cleansing, the base is readjusted to the crown, and then put in position on the cap and waxed firmly to it.

The crown is then removed and the cap invested, soldered and finished as described under banded crowns.

Where it is intended to use a facing, building up the lingual side with porcelain, the band and floor are made of iridio-platinum. The band on the lingual side should extend at least $\frac{1}{32}$ inch above the line of fracture. (Fig. 649.) On this side a floor should be fitted to the inside of the band over the broken face of the root, allowing the band to extend above it, but on the labial side it can be brought over the top of the band and well under the gum. The band extending above the floor of the cap on the lingual side forms a protected seat in which the porcelain is baked so that there will be no thin margins of porcelain which would be liable to crack and flake off. (Fig. 650.)

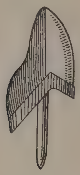
Fig. 648

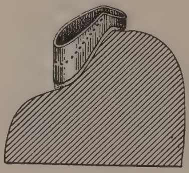
Fig. 649

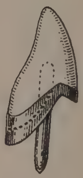
Fig. 650

Casting Directly on the Facings.—In making a single crown or a small bridge, where it is intended to cast directly against the facings, great care must be used that the wax does not overlap the porcelain at any point. This is of the utmost importance, as if the wax is extended so as to grip the facings, the contraction of the metal on cooling will be certain to crush them. The wax should be carefully trimmed to the edges of the porcelain, and it is a good plan to clean them well by rubbing the edges with a piece of tape or cloth before investing.

Drying Out and Heating Up the Flask.—The flask should be dried out carefully and then brought to a very high heat throughout so that the facing will be red hot when the molten gold comes in contact with it. If the facing is cold, or but slightly heated, when the casting takes place, the rapid expansion of the platinum pins, taking the heat so much more quickly than does the porcelain, would fracture the facing. After casting, the flask should be allowed to become perfectly cold before opening, after which the piece is cleansed and is ready for finishing.

The crown, or the bridge, which has been made in this way will be satisfactory, providing there is little or no strain on the facings, but unless this is the case the method is decidedly objectionable.

In a facing which is reheated in soldering or otherwise, the strength of the porcelain is diminished, and especially is this so if a mass of gold is forced upon it in a molten state. The piece may come out with the facings seemingly intact, but they have been weakened and in the majority of cases, if examined under a microscope, will show innumerable fine checks running all through them. It is far better not to subject the facings to this refiring, if it is possible to avoid it, as they are thereby rendered much more serviceable than they would be otherwise.

REPAIRING OF CROWNS.

When from any cause it is found necessary to remove a full gold crown from a tooth, if the crown has been properly fitted and cemented, it will generally be necessary to cut the band in order to get it off. This may be easily done, unless the band has been heavily covered with solder, with one of the crown slitters which are made for this purpose, as illustrated in Fig. 651. With one beak resting on the cusp and the other caught under the edge of the crown, the forceps are closed, dividing the band all of the way to the cusp, when by giving a slight rocking movement, the crown may generally be easily lifted off. Should this not be the case, an instrument is passed under the flap and worked around the tooth to remove the cement and the band gradually loosened (Fig. 652). A hatchet-shaped excavator can sometimes be used to do the cutting, the blade being drawn from the cervical edge to the cusp, until the band is divided. A small wheel bur will do

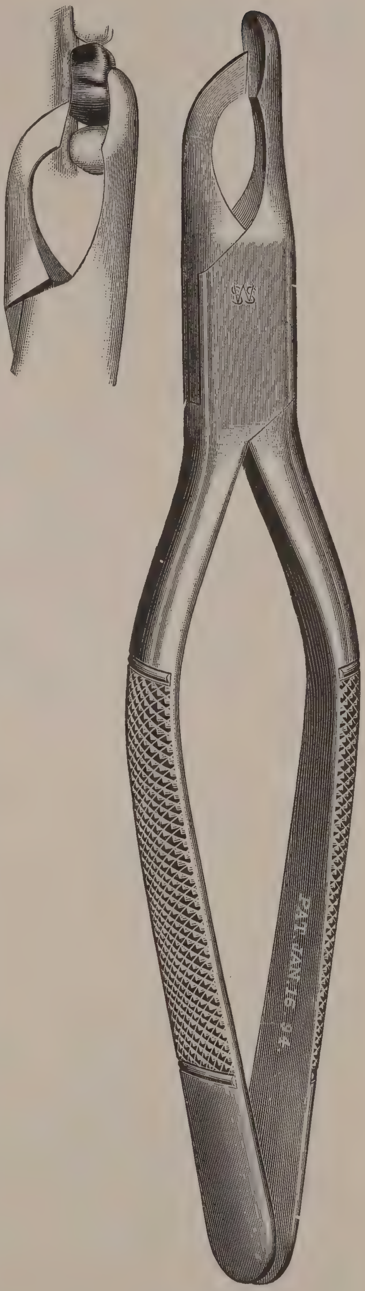

Fig. 651

the work, cutting from the cervix to the cusp in the same way as with an excavator.

In repairing the crown, the cement is thoroughly removed and the edges of the break brought into close contact and soldered. If there is much loss of material at the site of the cut, a narrow strip of thin platinum or of pure gold is waxed over the line of division on the inner side of the cap, which is then filled with investing material and the broken edges united with solder. (Fig. 653.)

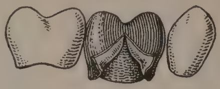
Fig. 652

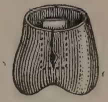
Fig. 653

The repairing of a porcelain-faced crown is a much more difficult operation. If the crown has been set with gutta-percha, it may be easily removed by grasping it with a heated pair of pliers or forceps, having first protected the lips and gums of the patient with napkins. If it has been set with oxyphosphate of zinc, much more trouble will be experienced in getting it off. It will be necessary first to separate the cap from the pin. This may be done by passing a drill from the labial side through the base of the backing and the floor of the cap to one side of the pin (Fig. 654) and then cutting the pin through with a very small fissure bur, after which the cap is easily pried off. To remove the post, the cement must be cut away from around it until it has become loosened. A very fine spear-pointed drill will do this best. The shank of one of the finest burs or of a Gates-Glidden drill, flattened on two sides and then ground to a spear point makes an excellent drill for this work, being smaller than any obtainable at the dental depots. The cement is drilled away close to the pin all around, inclining the drill toward the post at all times so as to weaken the root as little as possible by cutting into it. (Fig. 655.) From time to time an effort may be made to loosen the pin by grasping it with a pair of strong small-nosed pliers (Fig. 656) and trying to rotate it. If it will not loosen, the drilling is to be carried deeper until it can be removed. The remainder of the cement is then removed from the canal and a new pin fitted to it. The

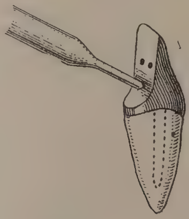
Fig. 654

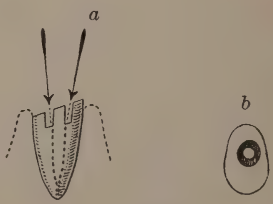

Fig. 655

palatal portion of the crown with the backing is then cut away, the cap placed on the root and the pin waxed in place. The cap and pin are now removed, invested and soldered, after which the facing is ground, backed and the crown soldered.

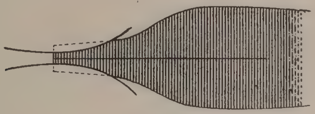

Fig. 656

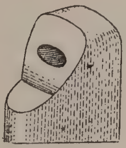

Fig. 657

There are several ways of replacing a facing in the mouth without removing the cap and pin from the root. A good way to do this where the remaining metal portion of the crown has sufficient thickness, is as follows: the remnants of the pins are first cut off and ground flush with the backing and an impression taken covering the backing and floor of the cap, and a cast made of plaster, cement or Spence metal. A hole is then cut in the back of the cast large enough for the pins to enter freely. (Fig. 657.) The facing is then selected and ground to fit the cast accurately. The backing of the crown or pontic in the mouth is then cut out to accommodate the pins, care being used not to come through on the lingual side. The cavity is then deeply undercut all around, making it strongly retentive in shape. (Figs. 658, 659, 660.) The pins of the facing are then flattened at the ends and bent at right angles, one being cut off so that it is a little shorter than the other so that when the long pin is inserted and the facing pressed as far to that side as it will go, the short pin will just pass through the opening in the backing. (Fig. 661). The cavity is now filled with cement and the backing and floor covered. The long pin is first introduced, the facing carried to that side until the shorter one will enter. It is now pressed tightly in place and then forced back until the sides of the facing are even with the backing. This will bring the ends of both the short and long pins under the ledge of the cavity and when the cement has hardened, it will be impossible to remove the facing except by breaking it. (Fig. 662.)

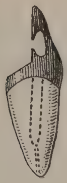

Fig. 658

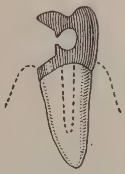

Fig. 659

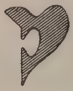

Fig. 660

Another method of repair in the mouth is by riveting a facing. It should first be fitted to a cast as described and a backing of tin-foil or paper fitted to it and trimmed carefully to the edge of the facing all around. This backing is then removed and placed in position over the gold backing of the crown in the mouth. (Fig. 663.) The holes in the backing will now show the exact position of the pins of the facing, and the holes may be drilled with a small spear-pointed drill the exact size of the pin. The holes are then countersunk from the palatal side and the pins cut off so that they will project only a slight distance through the backing. (Fig. 664.) The riveting is done with a plate punch. The facing is removed and the backing and floor of the cap are dried with alcohol and covered with cement of about the same consistence as that used in setting a crown. A piece of lead or a thickly folded napkin is placed over the facing and, with the die side of the punch resting on this, and while the cement is yet soft, the pin is riveted by rubbing and burnishing with the punch end of the forceps until the countersink is entirely filled. (Fig. 665.) After riveting, any excess platinum of the pin may be ground away and the back polished. If a facing is carefully riveted, the holes not being too large, this will make a stronger repair than can be made by any other method. If the cement has been allowed to harden before the riveting is done it will be broken and crumble away.

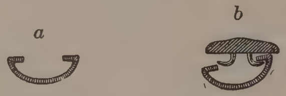

FIG. 661

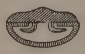

FIG. 662

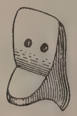

FIG. 663

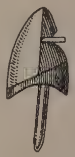

FIG. 664

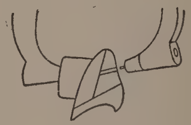

FIG. 665

Dr. Emory A. Bryant[1] describes a novel method of attaching a new facing. A tap and die the size of the tooth pins are necessary, together with a special countersinking tool and a screw-driver. The pins are cut from the old backing and holes are drilled the size of the pins of the new facing, and in the proper positions. With the countersinking tool held in a right-angle handpiece, the holes are countersunk exactly to the outer wall of the backing. The nuts are made the size of the countersunk portion. By means of the oiled die, a thread is cut on each pin of the tooth, and continued to the back of the facing, exercising great care that the pins are not twisted. The backing is covered with

[1] The Dental Cosmos, vol. **36**, p. 469, et seq.

cement, the facing set in position and each nut is loosely adjusted, then alternately screwed into place, drawing the facing close to the backing. The protruding portions of nuts and pins are then ground down and polished.

This method of replacing broken facings is very ingenious, but it is a question whether the cutting of a thread on such a small pin will not weaken it to such an extent as to render it of little value where much strength is required. It is better if the full strength of the pin can be preserved.

RETAINING MEDIA.

The zinc oxyphosphate employed in the setting of crowns or bridges should possess the characteristics which would recommend the specimens to be used as filling material, and should be what is known as a hydraulic cement. It should, however, flow freely, and, as the difficulty of maintaining dryness is increased, it should set promptly and yet with sufficient slowness to permit the accurate adaptation of the crowns.

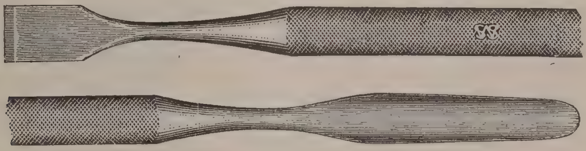

Fig. 666

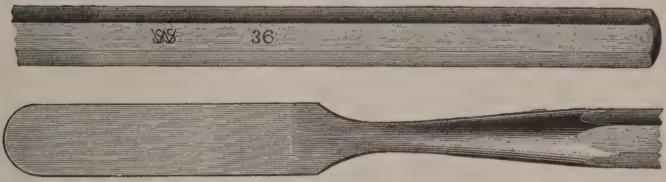

Fig. 667

The operator should be familiar with the peculiarities of the particular cement he is using, as specimens of the different makes and at times those of the same make, but of different batches of oxyphosphate, differ so markedly in their behavior, that it is unsafe to use them for this purpose without having first tested them.

The value of a cement depends as much, perhaps, upon the manner in which it is mixed as upon the kind of cement which is used. The cement should always be thoroughly spatulated. A little of the powder should be first well worked into the liquid, a very little of it being dissolved during the process. The powder is then added a little at a time, mixing it well until enough has been incorporated to give it the desired consistency and the whole mass is perfectly smooth and creamy.

The spatulas used should be strong and of ample size to do the work thoroughly. Fig. 666 shows a spatula suitable for single crowns or small bridges, but for large bridges, with several abutments, where a large mix is required, a spatula such as shown in Fig. 667 or one even larger, is indicated. In this case a large slab should be used. A piece of plate glass about $4\frac{1}{2}$ or five inches by 6 inches will answer nicely and is none too large.

SETTING CROWNS WITH ZINC OXYPHOSPHATE.

It is advisable to set all pin crowns so that they can be removed without mutilating them, if at some future time it should be desirable to do so for the purpose of repairing them, or in case they should be needed as anchorages for a bridge. An excellent method of setting them so that they will be perfectly rigid and at the same time render them easily detachable, is first to give the pin and the inside of the band a coating of chloro-percha. A solution may not always be at hand, and a convenient way to do this is to take a fine camel's-hair brush, dip it in chloroform and then rub it on base-plate gutta-percha and paint the cap and pin. The solution will dry very quickly and the crown is then set with oxyphosphate of zinc. If at any time it is desired to remove the crown, it can be easily done with a pair of heated forceps or pliers.

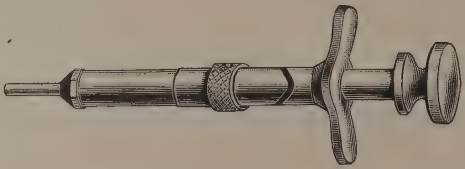

Fig. 668

The Cruttenden cement syringe (Fig. 668) is a most useful aid in cementing crowns or bridges, especially where several pin crowns, either single or as abutment pieces, are to be set at one time. It consists of a nickel-plated brass cylinder, with the needle or tube small enough to enter the enlarged canal, and a brass plunger. There is an opening in the side of the cylinder for the introduction of the cement. The root is thoroughly dried and the cement mixed to the consistence of thick cream and placed in the cylinder. The piston is then put in and the end of the needle carried to the end of the canal and the cement forced into it, withdrawing the needle slowly at the same time. In this way, the apical extremity of the canal is filled first and any air which may be in it is forced out. A number of roots may be filled in this way in a few seconds and there will be ample time to put the crowns or bridge in place before the cement has set.

As soon as the piece is in place, the syringe is plunged into a basin of cold water and the piston worked back and forth to free it from the remaining cement while this is still soft. If the cement is too hard to be forced out it may be removed with the drill which comes for this purpose.

SETTING CROWNS WITH GUTTA-PERCHA.

When gutta-percha is to be employed, it is necessary that the several parts shall be at a temperature which will permit the ready, deliberate, and accurate adjustment of the crown and gutta-percha to the root.

The crown is laid upon a gutta-percha heater. Dr. How's steatite slab is useful for the purpose (Fig. 669), or in the absence of this appliance, it may be heated over a small alcohol flame. A piece of base-plate gutta-percha is also laid on the slab, or heated over the flame of the lamp, and when soft is pressed out between the fingers into a sheet, which is wrapped around the heated post.

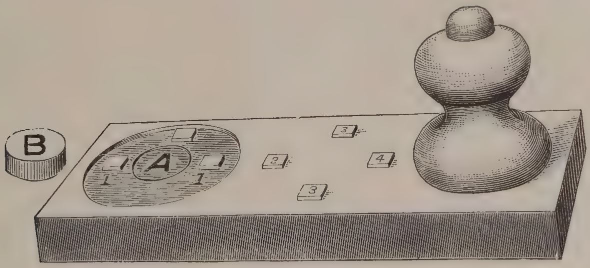

Fig. 669

The canal is moistened so that the crown may easily be removed and the crown forced on to the root as far as possible. It is then removed and the surplus gutta-percha, which has been squeezed out around the edge of the band, is removed, after which the canal is again moistened and the crown heated and pressed into place. This is repeated until the crown goes up to its normal position. It is then removed and cleansed and dried with alcohol and a very slight excess of gutta-percha is placed around the end of the pin. A napkin or cotton roll is now placed in position to keep the field of operation dry and the canal is dried thoroughly with alcohol and then wiped out very lightly with one of the essential oils, preferably eucalyptus. The crown is now again heated and forced up into place. Any excess of gutta-percha which may have been squeezed out over the margins of the crown is removed, and the work is completed.

CHAPTER XVI.

BRIDGEWORK.

By FREDERIC A. PEESO, D.D.S.

A DENTAL bridge consists of a continuous masticating surface, or of a succession of crowns or pontics having incisal edges. As its name implies, it is a bridge proper, depending for its retention and support upon the natural teeth or roots in the mouth, which serve as abutments. The success and the permanence of the device in this, as in the case of any other form of bridge, depends entirely upon the number, position and condition of the abutments.

The primary object of bridgework has been, and is, to do away with the inconveniences associated with an artificial denture, and to give patients an appliance which through its firmness and immobility will enable them to perform the masticatory function more perfectly than can possibly be done with an artificial denture.

The natural teeth or roots supporting a bridge are called the abutments, and the intervening portions are known as the body of the bridge. The body of the bridge is made up of one or more pieces representing the different teeth.

The idea of bridgework is not new. We find many traces, even among the ancients, of attempts to restore lost teeth. These early efforts were confined almost exclusively to fastening together with wire the crowns of natural teeth, and these in turn were bound to the remaining teeth in the mouth by wires. These restorations were entirely for esthetic purposes, and were of no practical value to the wearer for mastication.

Modern bridgework is of comparatively recent date, and it is only within the past thirty or forty years that it has been put to really practical use, and today it is recognized as being an important specialty of the dental profession. There is no form of denture made which so nearly approaches Nature in the restoration of the normal function of the lost organs.

CLASSIFICATION OF BRIDGES.

Dental bridges are divided into two primary classes, fixed and removable.

Fixed bridges are those which are attached to the abutments so that it is impossible for the patient to remove them, or even the dentist, without more or less mutilation of the abutment crowns.

Removable bridges are those which can be removed from the mouth by the patient for cleansing or other purposes, without interfering with or disturbing the stability or integrity of the appliance.

The insertion of dental bridgework requires the mutilation of the teeth, serving as abutments, to a greater or less extent, and in many cases the pulp must be sacrificed. This was at first considered as one of the great objections to bridgework, but it was simply a case of sacrificing one for the good of many. If the work was properly done, it was found that this sacrifice was justified in the increased comfort and improved health of the patient.

The value of bridgework is unquestionable. This value depends entirely upon the manner in which the work is done, and where it is used and not abused, there is nothing that can take its place.

Bridgework is not universal in its application, and is not intended to do away with all other forms of dentures, but it is unquestionable that in a large number of cases where partial dentures are being placed in the mouth, they are in reality an injury rather than a benefit to the patient, and bridgework is positively indicated and would render far greater service than is possible with the dentures which are given them.

REQUISITES OF A DENTAL BRIDGE.

The first requisite of a dental bridge is that it shall restore as nearly as possible the functions and appearance of the teeth which have been lost. Esthetic conditions are too frequently lost sight of in this work, but they are as important in this as in any prosthetic operation, and as much attention should be paid to esthetic effect as can be safely done without sacrificing the utility of the piece.

The crowns or facings which are to be used should be carefully selected, with due regard to their proper sizes, shapes, texture and shades. The occlusal surfaces should be made so that they shall effectively perform the work of mastication, and at the same time with no undue strain on the abutments or occluding teeth.

In fixed work, every portion of the bridge should be made with the idea of accessibility to the bristles of the toothbrush in cleansing, so that it may be kept as free as possible from foodstuffs and other dêbris. Spaces between the facings or crowns themselves, or between the body and the abutments in bridges restoring teeth in the posterior part of the mouth should be partially filled with gold and polished so as to offer as little lodgment for foreign substances as possible, and also to render it easier to remove any such substances which do find lodgment. Unnecessary exposure of gold is always to be avoided, and only in cases of extreme necessity in any bridge, placed anterior to the bicuspids, should gold be shown, and very rarely anterior to the molars.

No absolute rule can be formulated as to the amount of strain which any single tooth will stand, as there are so many factors of vital importance to be considered. The length and area of the roots of the teeth; their position in the arch, their relative positions to their antagonists all have an important bearing on this question. However, any one who does crown work and bridgework should have some understanding of the relative strength of the different teeth and approximately what might be expected of them under normal conditions and also as supports in carrying a bridge.

In the upper jaw, the central incisors are stronger teeth than the laterals. The canines are heavier, stronger and are more firmly implanted than the bicuspids, or any of the anterior teeth and constitute the best abutments. The bicuspids form good anchorages if too much is not expected of them. The first and second molars are very strong and make good abutments, but the third molars are more uncertain and cannot be depended upon to the same extent as the first and second. There are many times, however, when these teeth are exceptionally well rooted, firm and strong and will do their share of the work in supporting a bridge; but they should be examined carefully before deciding to utilize them. One probable reason for their frequent failure to render satisfactory service is the fact that as they are situated so far back in the mouth and are consequently so difficult of access for preparing, this latter operation is not thoroughly done and the bridge fails. The fact of their difficult accessibility should make the operator more careful and painstaking in their preparation.

In the lower jaw, the lateral incisors are stronger than the centrals, which are the weakest teeth in the mouth; notwithstanding this fact, the centrals are frequently of great value as abutments in those cases in which the placing of a bridge would be impossible without their use, The relative strength of the other teeth in this jaw is about the same as in the corresponding teeth of the upper jaw.

The form of the arch has a great deal to do with the carrying capacity of the teeth. A bridge which in one mouth would be of the utmost value to the patient, in another, with exactly the same anchorages, all in an equally good condition, but with the arch differently formed, might prove impractical or useless.

By uniting or splinting together several teeth, as in a bridge piece, the movement of each tooth is modified or restrained, and by such fixation two natural teeth are frequently found to withstand successfully more force than the sum of their individual resistances. As an illustration, observe a common condition in which a bridge is applied—a lower second bicuspid and a third molar serving as abutment teeth. If these teeth be healthy and have firm attachment, fixing to them a rigid bridge piece prevents the tendency toward antero-posterior displacement, one of the strongest elements tending toward their loss; they are held by the bridge so that the only possible movement is lateral.

If the lateral stress be correctly governed, such teeth may safely bear crowns upon their own roots, and support intervening crowns, filling the space between them, for a longer period than were a bridge not applied.

The Strain on a Bridge Occluding with an Artificial Denture.—Whether a bridge is to occlude with natural teeth, or with artificial teeth on an artificial denture, may properly have a deciding influence when considering its construction.

If the bridge is to occlude with teeth on an artificial denture it can be made longer, and with weaker abutments than would be safe were it to occlude with natural teeth, as the force of mastication is far less where an artificial denture is worn than where the natural teeth are standing.

Bridgework should be constructed upon sound mechanical principles. To be successful as a piece of engineering work, all designs are to be founded upon those principles. These fixtures are literally bridges, a continuous surface supported by rigid abutments, designed to bear safely the amount of stress it is calculated the piece will be subjected to. The calculations involve the strength of abutments, crowns, and body of the bridge. Violations of sound engineering principles are common in suggested devices. The students should examine carefully all proposed designs and select only those which are mechanically good.

An engineer recognizes that the stability and permanence of his bridge depends primarily upon the strength and position of its abutments. If these be badly built or poorly sustained, the bridge fails; so that bases are selected and prepared, abutments built, with due regard for the weight they are to sustain, and the resistance they are to afford.

It is not possible for one to specify all of the situations for which bridgework is suitable, but there are some typical cases which are frequently presented that will be considered. No two cases are alike and each one should be studied by itself and a judgment formed according to the conditions existing in the individual case. We shall begin at the anterior part of the mouth.

Where the two lateral incisors have been lost, the central roots may be safely trusted to support both lateral pontics, but it would not be reasonable to expect them to do more. Where the centrals are missing, the lateral roots are usually sufficiently strong to carry a bridge restoring the former, but in the case of an exaggerated V-shaped arch, the leverage of such a bridge might cause sufficient strain on the roots to dislodge them. In either of these cases, it is best to get some additional support in the way of a spur resting on the lingual side of the canines. A right central incisor and left lateral incisor will carry the left central and right lateral pontics and *vice versa*. (Fig. 670.) Where all of the incisors have been lost, if the arch is broad and the canines stand well apart, so that the teeth to be restored may be placed in nearly a straight line, a serviceable bridge may be made with a reasonable expectancy that it will last for many years. (Fig. 671.)

Where the arch is very narrow or V-shaped and the canines are close together, so that the incisors have to be placed in a marked curve outward, projecting far beyond the line of the abutments, it would be risking a great deal to trust to the canines alone to carry such a bridge. (Fig. 672.) If the bridge is extended so as to take in the bicuspids, it will make a much stronger piece, as these two additional anchorages will render it more rigid, and the resistance of the broad masticating surfaces of the bicuspids will make it less liable to tilt upward in the front as shown in Fig. 673. These conditions obtain more especially in cases of fixed bridges.

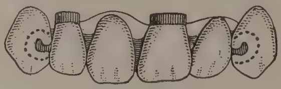
FIG. 670

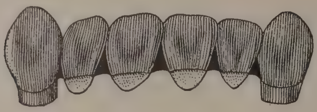
FIG. 671

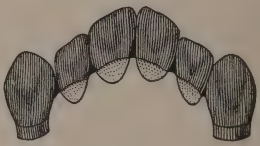
FIG. 672

It should be remembered that we cannot have too many supports, and that every additional abutment adds just so much to the chances of long life for the bridge.

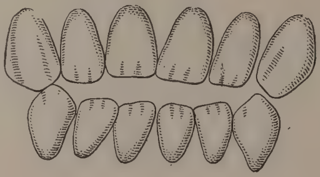
FIG. 673

Another typical case is where the first bicuspid and first molar have been lost, as in Fig. 674. In this case, ordinarily the second bicuspid and second molar would be sufficient as abutments, unless the bicuspid had moved back toward the second molar, so as to leave a much greater space than could be filled by a single bicuspid pontic; in which event the cuspid should be used as an additional supporting abutment as the increased leverage of the pontics would be too great a strain on the

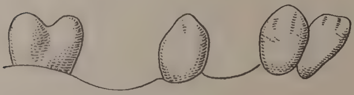
FIG. 674

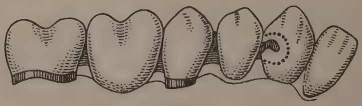
FIG. 675

bicuspid abutment, Fig. 675. The same plan should be followed where the two bicuspids are missng and the two molars are used as abutments.

Where a single bicuspid or a single molar is missing, as a rule there need be but a single retaining abutment, but the other end of the bridge should have a support, such as a spur resting in a filling or an inlay.

Where the six anterior teeth are lost, it is perhaps as well to give up the thought of bridgework and to trust to a partial denture; however, under certain conditions a satisfactory removable bridge might be made for the case.

To place a bridge from the canine to the first molar, or even to the second, is good practice, and at times it might even be extended to the third. The first or second bicuspid and the second or third molar will give good support. Where all of the molars are lost, they can only be restored with the removable type of bridge.

In order to restore the full set of teeth in the upper jaw, there should be at least four good strong roots to serve as abutments, as for example, the two canines and a first or second molar on each side. Where the two central incisor roots are also in position, of course, they give greater strength to the piece and each additional root adds just so much to the chances of long life for the bridge.

A larger bridge may be placed on the same number of roots in the lower jaw than in the upper, as, having gravity in its favor, the choice of a saddle piece is possible, which could not be thought of in the upper jaw. Of course, it must be made removable.

Physiological Aspect.—The physiological aspect of bridgework, although belonging properly to works upon dental pathology, must form part of every treatise upon such a combination of surgery and mechanics as bridgework represents. It includes the consideration of all of the vital relations of the abutment teeth, the contiguous parts, and, it may be, of more general vital relations. Anything directly or indirectly bearing upon the subject of dental hygiene is an item for consideration in the pursuit of this work.

Preparation of Abutments.—First and most important, any root or tooth which it is designed to make an abutment of a dental bridge should have such preliminary treatment as will bring it to a condition of health. The directions given as to the preparation of roots for the reception of artificial crowns apply with redoubled force when these roots are to be abutments. The same requirements as to perfect adaptation of individual crowns also obtain when such pieces are to serve as the abutment crowns of bridges. The contact of every crown edge with its base should be perfect, and each crown should represent as carefully made and adjusted piece as were the same crown to stand alone.

THE CONSTRUCTION OF BRIDGES.

We shall now consider the making of a bridge and shall select as a common type, a skeleton bridge having two full gold crowns, or one full gold crown and a Richmond crown as abutments and carrying one or more pontics. (Fig. 676.) The abutment pieces having been adjusted to their respective positions, the impression and articulation are taken and the cast prepared in the manner already described.

In selecting the facings for the case, it is desirable to choose them of such length that when they are ground into place, the necks will just touch the gum lightly and the occlusal edges will be in contact with the antagonizing teeth. (Fig. 677.) They are ground to follow the gum line and should not be in actual contact with each other. After they have been ground into place, a wall of plaster is built up on the buccal side of the cast to retain them in position. (Fig. 677.) After the plaster has hardened, the facings are removed, and their occlusal ends ground off about $\frac{1}{32}$ inch and at an angle of about 45 degrees with the back of the facing. (Fig. 678.) The line of their occlusal ends should be continuous, that is, the bevel of one facing should not be higher than another. The facings are then to be backed and for this purpose, thin platinum, or pure gold may be used. The gold will have a tendency to lighten the color of the facing and give it a slightly yellower cast, while the platinum will tend to darken it and impart a bluish tint. If the backing is of platinum, it may be very thin, about $\frac{3}{1000}$ inch. It should extend from the inner edge of the bevel at the occlusal end to and about $\frac{1}{16}$ inch over the lower edge where it has been ground to fit the gum. The backing of each facing should touch, or slightly overlap, that of the one next adjoining and those of the end facings

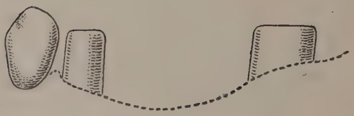
Fig. 676

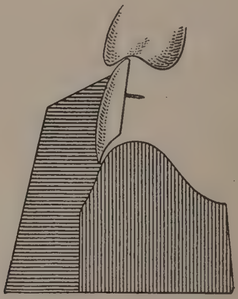
Fig. 677

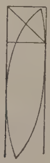
Fig. 678

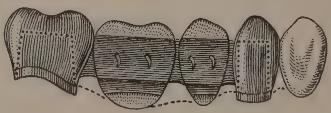
Fig. 679

should be in contact with the abutment crowns. The pins are flattened with a pair of pin-roughening pliers, and are bent down over the backing, thus pressing it close to the facing. (Fig. 679.) The facings are then waxed together and to the abutment crowns with hard adhesive wax, a piece of oiled paper being placed underneath on the surface of the cast to prevent their attachment to it. The wax should be built up high enough to support the cusps for the pontics. Suitable solid cusps are then made, ground or filed to fit the bevel of the facings, and fastened in place with adhesive wax. (Fig. 680.)

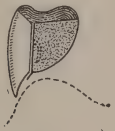
Fig. 680

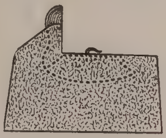
Fig. 681

The bridge is now ready for investing and soldering. It is taken from the model, the inner cap being removed also if it be a removable bridge, and the inside of the abutment pieces filled with the investing material and the whole bridge partly imbedded in it with the facings down. The investment should come over the backings which extend beyond the lower angle of the facings, holding them in place and preventing their springing up, and nearly to the lingual edge of the cusp (Fig. 681) and should be small; only large enough to hold the parts together. The abutment crowns are partly covered to protect them from the flame.

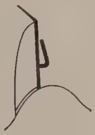
Fig. 682

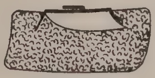
Fig. 683

In grinding the facings for the pontics for any of the six anterior teeth, they should be made to set closely to the model and, after they are properly fitted, a wall of plaster is made on the labial side. The facings are then backed, the backings extending over the beveled portion at the neck and about $\frac{1}{16}$ inch beyond the incisal edge (Fig. 682), and the pins flattened and bent toward this edge close to the backing. In investing, the investment should cover the extending portion of the backing to prevent its warping. (Fig. 683.)

Bridges of three or four teeth may be soldered in one piece, but large cases should be soldered in sections. This is because the contraction of large masses of solder when the piece cools has the effect of disturbing the relation of the abutment pieces, and the bridge in consequence

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has its fit impaired. A full bridge of twelve to fourteen teeth should be soldered in three or four sections. If in three, the incisors may be soldered in one piece, and the sides from the canines back separately. If in four sections, the central, lateral and canine of each side separately and then the side bridges. The different sections are finished and polished except where they are to be united. They are then replaced on the model, waxed together with adhesive wax and a strong iron or brass wire bent to conform to the lingual side of the bridge and waxed firmly to the different parts. This will hold them firmly in their proper relative positions and prevent them from springing while being removed from the model and invested. The bridge is then invested, the divisions between the several sections being freely exposed and the parts united with the same, or a slightly lower carat solder than has been used in the previous soldering. When the investment has cooled, the bridge is removed, pickled in dilute sulphuric acid and finished.

Selection of Facings.—In choosing the facings or crowns for a bridge, or in fact for any form of partial denture, the greatest care should be used to select those of proper mold and shade. If it is impossible to get a crown or a facing to match exactly the shade of the natural teeth, it is better that it should be slightly darker rather than lighter than these. If a crown is the least bit too light in color it is conspicuous and is the first thing seen when the patient opens the mouth, while if it is but slightly darker than the neighboring teeth, it is not so noticeable.

In restoring the six anterior teeth, the facings should never be bought in sets as put up by the manufacturers. In the human mouth, these teeth are never all of the same shade. The central incisors have generally a yellowish cast. The laterals are of the same general shade, but are clearer at the tip with a slightly bluish tint, while the canines are the yellowest teeth in the mouth anterior to the molars. If the facings restoring these teeth are all of one color, they will never present a natural appearance, since their uniformity will at once advertise their artificial nature. They should be selected in pairs, the centrals, laterals and canines, each from a different set in accordance with the natural shading of these teeth.

As we go farther back in the mouth, we find the bicuspids more on the order of the laterals, clear at the tips with a bluish cast, while the molars are yellow. In selecting these teeth, the bicuspids, especially the first, should be matched as nearly as possible. With the molars there is not the same necessity of being so exact. They should be of the same general shade and may be darker than the natural teeth, but blend well, but certainly not lighter.

The shape of the teeth should be studied carefully and the form of those lost should be copied as nearly as possible by their substitutes. In replacing the teeth on one side of the mouth, a careful impression of the natural crowns on the opposite side should be taken and a model prepared so that it will be possible to accurately reproduce them. A flat facing should never be used to restore a tooth which had a rounded face. (Figs. 684 to 687.) The remaining natural teeth will here again serve as an index for the form of the selected facings.

FIG. 684

FIG. 685

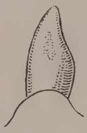
FIG. 686

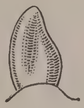
FIG. 687

Occlusion.—In addition to its other requirements, the articulation of a bridge piece must be as nearly perfect as it is possible to make it. A bridge which is properly articulated will not only be more effective than one faulty in this regard, but its use will be attended with less liability of loosening or injuring the abutments.

A large percentage of the cases of bridgework are for the posterior part of the mouth and the dentist is most frequently called upon to restore lost molars and bicuspids. Where these teeth, in either jaw, have been lost for any length of time their antagonists in the opposite jaw are sure to have become elongated to a greater or less extent (Fig. 688), and if no measure is undertaken to prevent it they will eventually be exfoliated. The normal line of occlusion must be restored in a case of this description, if a satisfactory denture is to be made to replace the lost teeth, whether it be a partial denture or a bridge. If a bridge is constructed without doing this, it can be never so serviceable to the patient as where the occlusion has been made normal. The triturating motion so necessary for the perfect performance of the masticatory function, is interfered with or prevented altogether, the only movements possible being the opening and closing of the jaws in which the food may be pressed or crushed, but not ground. The moment the mandible is thrust the least bit forward, the jaws are thrown apart and the only point of contact is the distal cusp of the elongated molar with the mesial cusp of the lower molar opposite. (Fig. 689.) Where this elongation of the teeth has taken place, the cusps must be ground away to the normal line of occlusion and the teeth carved so as to reproduce as nearly as possible the original cusps. If they have become very much elongated, it may be necessary to devitalize the pulps and crown them, or to restore their masticating surfaces by building up with gold.

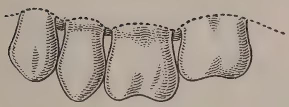
FIG. 688

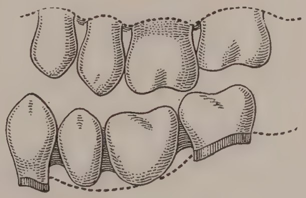
FIG. 689

EXTENSION BRIDGES.

In a very large majority of the smaller extension bridges which are made, where the whole or a portion of the body of the bridge extends beyond the single abutment, as in Figs 690 and 691, the entire principle is faulty and the whole piece a mechanical impossibility. Notwithstanding this, pieces of this description are placed in mouths to the detriment of the patients. Sooner or later the abutments to which these pieces are anchored are sure to be forced out of their normal position and frequently are lost. In the anterior part of the mouth, where an appliance, such as shown in Fig. 691 has been inserted, the rotation and consequent loosening of the root is inevitable.

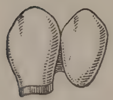

Fig. 690

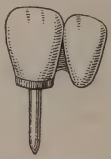

Fig. 691

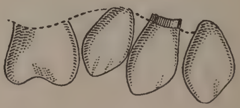

Fig. 692

In Fig. 692, where a pontic having an occlusal surface is attached to a single abutment there is not only a strong lateral strain which will give a constant twisting motion to the root, but there is also a direct force which is being continually exerted, gradually tilting the abutment and forcing the pontic into the tissues (Fig. 692) with the resultant loss of occlusion and the eventual loss of the root to which the bridge is attached.

One inflexible rule applies in all of these cases and that is that *there must always be a support at each end of a bridge and never under any consideration should a single point of attachment be depended upon to carry a pontic.*

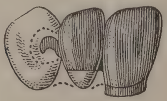

Fig. 693

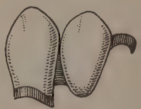

Fig. 694

A small spur of platinized gold or iridio-platinum, attached to the lingual side of the pontic, and resting in a small gold filling or inlay on the lingual side of an adjoining tooth, as shown in Fig. 693, will entirely overcome the possibility of rotation, and will make the piece a permanent fixture rather than a temporary one.

A spur resting in the lingual side of the cuspid or in a filling or inlay in the fissure of a molar or bicuspid (Fig. 694), will effectually prevent future trouble and render a piece serviceable which would otherwise be worthless.

Extension Bridges with Saddles.—Extension bridges, in which saddles, resting on the ridge, are employed as an additional support, should never be used in fixed bridges, as it is impossible to properly cleanse an appliance of this kind. Irritation and inflammation are sure to ensue, and its use will sooner or later result in the loss of the abutment teeth, if not in troubles of a more serious nature.

ATTACHMENTS FOR REMOVABLE BRIDGEWORK.

Retaining and Supporting Abutments.—There are two classes of abutments in both fixed and removable bridgework, and these are known respectively as retaining abutments, and supporting abutments.

By a retaining abutment is meant an abutment which not only gives support to the bridge, but also retains it in its proper position in the mouth, as in the case of a Richmond crown, shell crown, telescope crown and others of a similar character.

A supporting abutment is one which gives support to the bridge, but has nothing to do with its retention. An example of an abutment of this kind would be where a spur is resting in a gold filling or in an inlay in an adjoining tooth, and serving simply to prevent any lateral movement and to resist the force of occlusion.

RETAINING ABUTMENTS FOR REMOVABLE BRIDGEWORK.

Of the different styles of abutments which may be utilized in removable bridgework, the telescope crown is probably the one most frequently indicated. The telescope crown should not be confounded with the shell crown. The shell, or full gold crown simply covers the tooth or root and is used as a single crown, or as an abutment in fixed bridgework. In the telescope crown, there are two caps, one telescoping and fitting into the other as exactly as the tubes or slides of a telescope, the inner cap of which is cemented to the tooth serving as an abutment. This crown is only used in removable bridgework. It is indicated for molars and bicuspids where a full gold crown can be used, but should never be employed in the front of the mouth. The tooth for the reception of a telescope crown should be prepared in exactly the same way as for a full gold crown, with the exception that a little more of the tooth structure should be ground away from the occlusal surface. The sides should be trimmed so that the tooth is very slightly conical, its greatest circumference being about $\frac{1}{16}$ inch below the gum line.

It is not necessary that the abutments should be absolutely parallel, but they must be very nearly so. Advantage may be taken of the natural inclination of the teeth. If they are diverging, they may be ground so that when the bridge is put in place, the teeth will be drawn together slightly and spring back as it is pressed home. If the teeth converge they will be forced a little apart. This slight natural spring of the teeth will assist in holding the bridge firmly in place, but it must be very slight, otherwise the removal and replacing of the bridge would have a tendency to loosen the roots.

The telescope crown should be made of coin gold, or some very hard alloy of that metal. The regular 22-carat plate as purchased at the dental depots is too soft to withstand the strain and wear to which it will be subjected. If the telescope crown be accurately made of a rigid material like coin gold, there will be practically no wear on it, even after years of use. The fluids of the mouth seem to form a coating which prevents the actual contact of the metal in the two caps, however closely they may fit, but if the material of which the bands are made be so soft as to allow them to stretch in the slightest degree, this would render the piece worthless in a comparatively short time.

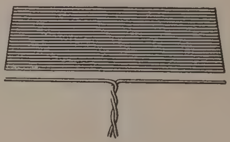

Fig. 695

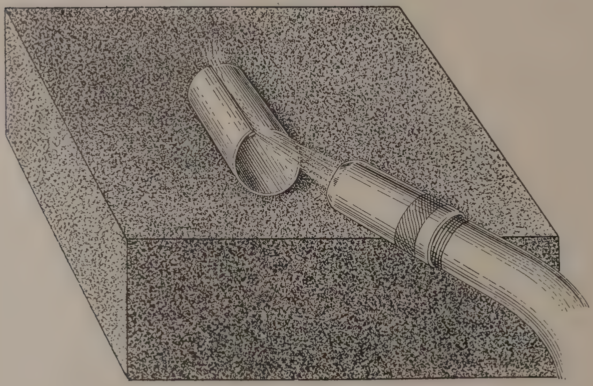

Fig. 696

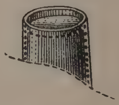

Fig. 697

The band of coin gold No. 30 gauge is cut on an angle as shown in Fig. 695, beveled and sweated together. (Fig. 696.) It is made to conform to the tooth, the sides being nearly parallel, or slightly diverging toward the neck, and it is festooned to follow the gum line so that it will go an equal distance under the free margin of the gum all around. It is then cut off even with the top of the root; the extreme occlusal edge of the band turned in slightly (Fig. 697) and filed perfectly flat and a floor of No. 28 coin gold is sweated to it. In sweating the floor to the band, the former is first flattened so that there will be close contact between it and the band all around. It is then fluxed on the inside and held by one corner in a pair of finely pointed pliers over a Bunsen flame until the parts are united. The surplus gold of the floor is then trimmed away, the edges at the occlusal end slightly rounded and the sides of the cap polished. We now have what is practically a seamless crown and are ready to make the outer cap. As a first step, the inside of the cap is given a very thin coating of melted wax to prevent its union with the fusible metal which is to be poured in it. It is then pushed into a paper tube, which can be made by rolling a piece of paper around a lead pencil or stick of suitable size, held together with a small gum elastic band, and the cap and the tube filled with fusible metal. (Fig. 698.) This renders the cap perfectly solid so that it is impossible to crush it. A new measurement is taken at about the middle of the cap and the gold for the outer band is cut a little shorter than the measurement and slightly tapering, so that the band will be a little larger toward the neck, and its ends sweated together.

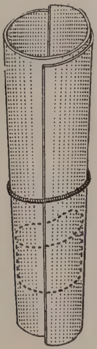

Fig. 698

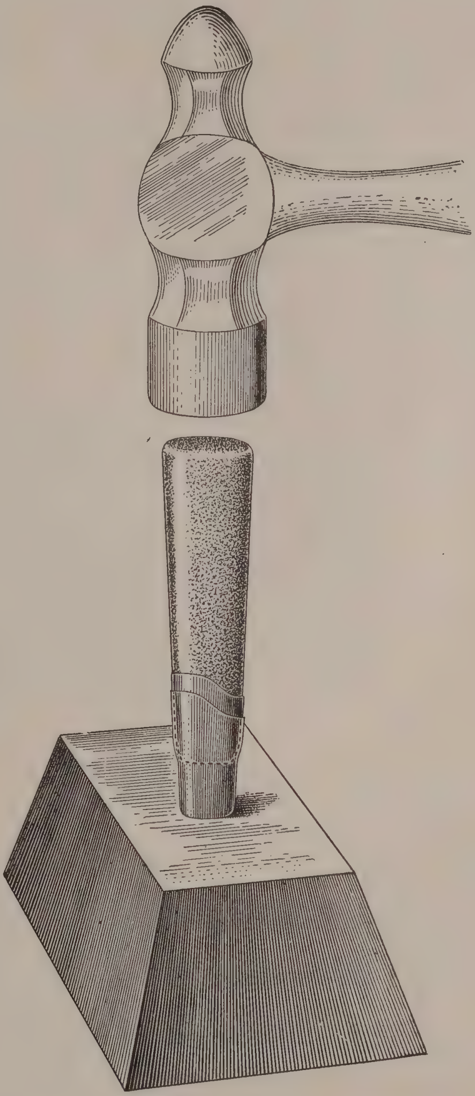

Fig. 699

It is festooned to follow the lower edge of the inner cap and forcibly driven over it to within about $\frac{1}{16}$ inch of this edge. (Fig. 699.)

The band is then cut just a little above the floor of the inner cap and pressed in all around the edge so that it fits closely at the point (Fig. 700), after which it is filed flush with the floor of the inner cap. It is then removed and a floor of No. 30 coin gold is sweated to it. The extending edges of the floor are then trimmed flush with the sides of the band and it is ready for the contour.

This is made by building it on the outside of the band. A piece of No. 28 coin gold is cut, its width being about the same as the width of the outer band and its length about twice the diameter of the cap. (Fig. 701.) The lower edge of this is then bent slightly inward, as it is desirable that the solder used should not unite the piece all the way up the band, but should catch it only at the extreme edge as in Fig. 702. The contour piece is then placed on the band, the lower edge coming only about $\frac{1}{32}$ inch from the lower edge of the band, fluxed and soldered with a very small piece of 22-carat solder (Fig. 703), using the small blue point of the blowpipe flame. It is then cleansed in acid and another piece attached to the opposite side in the same manner. These contour pieces are always attached to the mesial and distal sides of the cap. The cap with the wings attached is placed on the inner cap and the wings thrown out to the desired angle, and the ends turned in at the buccal and lingual sides so as to give a natural contour to the crown. (Figs. 704, 705 and 706.) The crown is then well fluxed between the contour pieces and the band and along the edges of the wings, and the whole soldered with 22-carat solder, partly filling the space between the wings and the band.

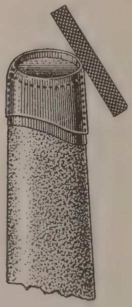
FIG. 700

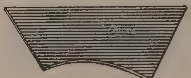
FIG. 701

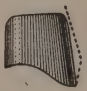
FIG. 702

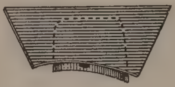
FIG. 703

This is done by laying the crown on a charcoal block and placing the pieces of solder on the buccal and lingual sides between the ends of the two plates (Fig. 707), and drawing it down on each side with the small flame of the blowpipe. The surplus gold of the contour wings is then cut away and the contour filed flush with the floor of the cap.

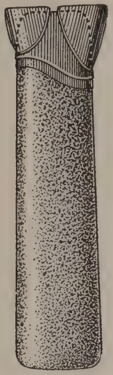

Fig. 704

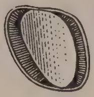

Fig. 705

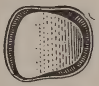

Fig. 706

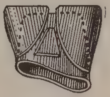

Fig. 707

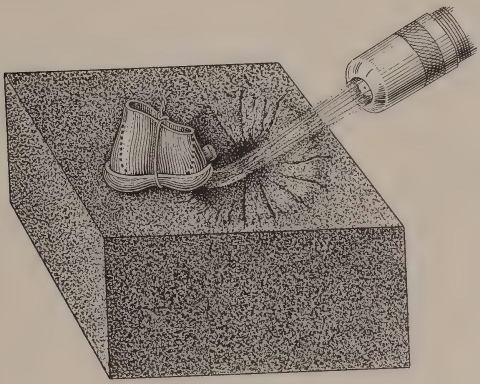

Fig. 708

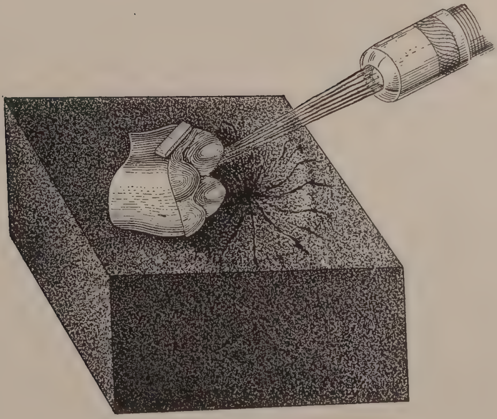

Fig. 709

A suitable cusp is then made, and its under surface filed flat to fit the top of the cap. The cusp and cap are then fluxed, wired together and soldered with 20-carat solder, laying the crown on its side on a charcoal block, the piece of solder on the band in contact with the cusp, and soldering with the small flame of the blowpipe. (Figs. 708 and 709.)

Where the teeth are short or where there is to be but one retaining abutment, a combination of the telescope cap with a tube and split pin forms a most excellent attachment. The inner band is made as for the regular telescope crown. A hole is then made in its floor and a tube set in, resting on the floor of the pulp chamber and waxed firmly in place. (Fig. 710.) In adjusting the tube, care must be used to have its long axis exactly parallel with the sides of the band. The cap is then filled with investment material and the tube soldered in place with 20-carat solder. The tube is now cut off flush with the floor of the cap and the cap polished. The inside of the cap is now coated very thinly with wax and it is filled with fusible metal as already described.

The outer band is made and contoured exactly the same as for a regular telescope crown, the top filed perfectly flat, and a floor of No. 30 coin gold sweated to it.

The position of the opening of the tube is ascertained by placing the outer cap in position on the inner cap and with a soft pine stick and hammer tapping the floor directly over the mouth of the tube. (Fig. 711.)

When the outer cap is removed, the outline of the hole will be clearly defined on the inner side of the floor and may be punched or drilled to the proper size for the reception of the pin. The split pin is then made to fit the tube easily but not loosely, but should fit the hole in the floor of the outer cap tightly and be fastened to it with hard wax while the parts are in position. The cap is then removed, filled with investment material and the pin soldered to the floor with a very small piece of 22-carat solder. (Fig. 712.) The surplus pin is cut away nearly to the floor of the cap. The cusp is then selected, the under surface filed flat and a hole drilled through it to receive the part of the pin which projects above the floor of the cap. (Fig. 713.) They are then wired together, invested and soldered, feeding the solder through the hole in the cusp and drawing it all around the cusp until the cusp and cap

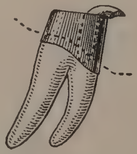
Fig. 710

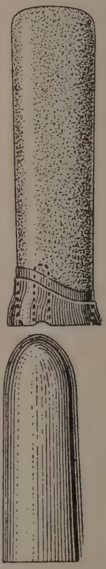
Fig. 711

are thoroughly united. (Fig. 714.) This attachment is especially useful in molars or bicuspids where the crowns are very short.

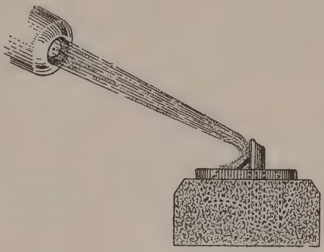

Fig. 712

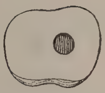

Fig. 713

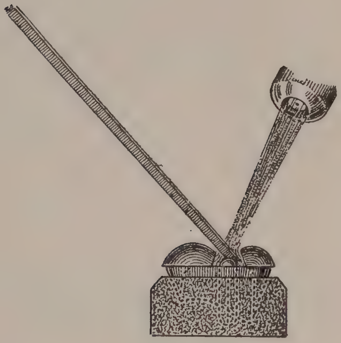

Fig. 714

INLAY ABUTMENTS.

Inlay Abutments for Anterior Teeth.—In making inlays for the canines or central incisors, the lingual surface is cut away on the side to which the bridge is to be attached and about two-thirds the distance across the crown, cutting down to, or near the gingival margin to give sufficient bulk to the inlay to insure adequate support for the bridge. (Figs. 715 and 716.)

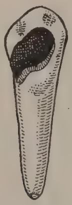

Fig. 715

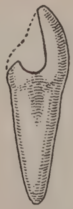

Fig. 716

The edges of the cavity are beveled so that the gold will overlap a little and give increased strength to the attachment and also to reinforce the crown of the tooth. The canal is enlarged about one-third the length of the root so that it will take a No. 4 or a No. 5 tube.

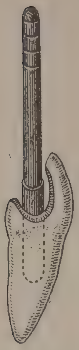
Fig. 717

The cavity is then moistened and the tube, with the mandrel in it, is inserted. The tube is then pressed lingually as in Fig. 717 and hot wax is flowed into the cavity from a spatula so that it will pass around and become well attached to the tube. It is pressed well to the margins and carved to reproduce the natural contour of the tooth. It is then removed and the mandrel removed from the tube by grasping it in a pin-vise (Fig. 718), and pushing against the end of the tube with a knife or a sharp-edged instrument and the sprue-former attached a little to one side of the tube. (Fig. 719.)

The lower end of the tube is gripped in the pin-vise and the tube is packed with asbestos paper so that no gold can be forced into it when the inlay is cast.

It is then flasked and cast in a very hot flask, so that the gold will be well attached to the tube. Pure gold is preferred for these inlays, as it can be burnished to the margins of the cavity better than an alloy. After it has been removed, it is placed in hydrofluoric acid for a time and then washed and dried.

The surplus tubing is now cut away and the inlay placed in the tooth and ground so that it just clears the occluding teeth, when it is removed and prepared for the second inlay.

The cavity is shaped the same as for the first inlay, allowing a sufficient margin of gold all around to give strength to the attachment. (Fig. 720.)

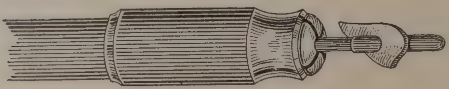
Fig. 718

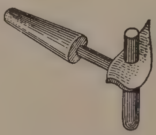
Fig. 719

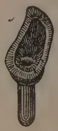
Fig. 720

The entrance to the tube is countersunk and rounded, and the inlay is polished so that there will be no sharp edge to scrape the plaster when the impression is taken. It is now placed in the tooth and the impression and bite taken. When the plaster has hardened, it is removed from the mouth and the inlay is replaced in the impression very carefully so that it goes exactly in place. It is fastened firmly at two or three points with a little sticky wax and a thin film of pink paraffin and wax is placed around the tube.

The impression is then varnished and the inlay coated very lightly with cocoa butter and the model made and articulated the same as for an ordinary bridge. Then, the inlay is removed by heating it slightly and the model is thoroughly dried out and hardened by soaking with thin sandarac varnish and drying again.

The next step is the fitting of the split pin. It is made as described later except that it is about twice the length of the tube and the line of contact is much longer (Fig. 721), so that the point of union where the pin has been soldered will come just below the entrance to the tube.

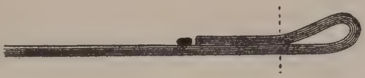

Fig. 721

It is carefully fitted to the tube and marked just at the entrance from the floor. (Fig. 722.) It is then removed and annealed and the closed end grasped in the pin-vise just a little above the mark showing the depth of the tube and bent with pliers or by pressing it against the edge of the bench. (Fig. 723.) It should be bent in the direction of the split and the end filed open, filing in the same direction and rounding it nicely. The second inlay can be made by casting or making a matrix and filling with gold.

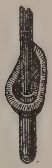

Fig. 722

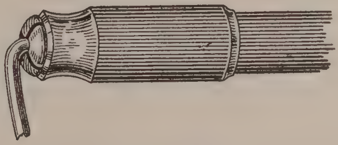

Fig. 723

In using the casting method, the cavity is lightly wiped with cocoa butter, the pin put in place and a little hot inlay wax poured from the spatula around the pin and over the floor of the cavity; more wax, not so hot, is added and packed in tightly until it is cool. The sprue-former is now attached and the wax inlay with the pin is removed and cast with coin gold in a hot flask. This makes a good inlay, but it is not apt to be as smooth and well-fitting as one made with a matrix.

With the latter method, the inlay with tube is embedded in a small piece of hard modeling composition and after it has been chilled, a matrix of pure gold, about 36-gauge is carefully burnished into it, letting it extend over the margins. It is annealed repeatedly and when it fits nicely, a hole is made in the base, over the entrance to the tube. The split pin is then put in place and the matrix is filled with hot sticky wax, which is allowed to cool and then pressed in tightly, using considerable pressure and forcing it closely against the floor and margins. It is then removed and invested as shown in Fig. 724. It is now heated up to a red heat and a little button of coin gold large enough to fill it is placed on the pin and melted into the matrix. It is then cleaned, placed in the first inlay and finished. In finishing, the grinding should always be from center toward the margins as shown in Fig. 725. If it were ground from the outside toward the center, it would burnish the gold of the outer inlay over the margins of the inner inlay so that it would be very difficult to separate them. The bridge is then constructed and the extending pin and side of the inlay waxed firmly to it. The whole piece is then chilled and the outer inlay removed. Before investing, the exposed surfaces of the inlay are coated with whiting to prevent the solder from flowing over the margin and destroying the fit.

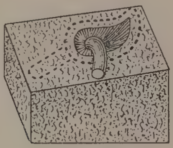
Fig. 724

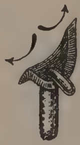
Fig. 725

Inlay Attachments for Molars.—These attachments for molars are made in exactly the same way as for the anterior teeth. The cavity is cut out of the occlusal surface about one-half the length of the crown and on the mesial side down to or near the gingival margin. (Figs. 726 and 727.) The tube should go to the floor of the pulp chamber or, if the crown is short, a little distance down the mesial root, as shown in Fig. 728, where a combination of a telescope crown and a tube and split pin is to be used. The cavity must be non-retentive and moist. The tube is put in place and the cavity filled with inlay wax and the wax roughly carved. It is then removed, the tube filled with asbestos paper, the sprue-former attached and it is flasked and cast, after which it is placed in the mouth and articulated. It is then removed and the cavity for the second inlay made and polished. This cavity should be shaped something like a keyhole. It is now replaced in the tooth and the impression and bite taken and the model prepared. From this on, the work is done as already described in making the inlays for the anterior teeth.

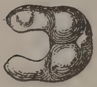
Fig. 726

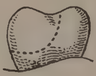
Fig. 727

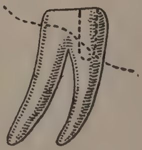
Fig. 728

In small bridges where great strength is not required, the second inlay is not necessary. The first inlay is made just the same as though a second inlay were intended. A groove is made the size and depth of the inside diameter of the tube, extending from the tube through the side of the inlay approximating the bridge. This groove is polished and the entrance to the tube rounded. The split pin is then made, and bent so that it lies in the bottom of the groove and the extending surplus is soldered into the bridge. If this attachment is carefully and accurately made, it is practically as good as the double inlay unless subjected to a very great strain.

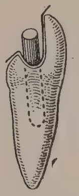

FIG. 729

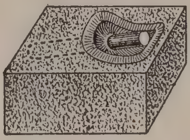

FIG. 730

In the absence of facilities for casting, the inlay abutment can be made as follows: The cavity is prepared as before described and the canal opened to receive a No. 4 or No. 5 tube. A matrix of pure gold of No. 34 or 36 gauge is then burnished into the cavity, annealing it frequently to insure a perfect fit, letting it extend a little beyond the margins. (Fig. 729.) A hole is then made to allow for the introduction of the tube into the enlarged canal. The matrix and tube are then placed in position, and hard sticky wax is run into the matrix and around the tube and is packed tightly against the margins. (Fig. 729.) It is then removed, the tube filled with asbestos paper, invested and filled with coin gold (Fig. 730). If platinum foil is used for the matrix, it can be filled with pure gold. It is now shaped for the second inlay which is made as already described.

Another form of anchorage which has given great satisfaction is the inlay attachment. In this type of abutment the natural crown of the tooth is preserved and it is especially applicable to pulpless canines, upper central incisors and molars.

Another style of abutment, especially adapted to bicuspids and molars having long crowns, is the dovetailed key and shoe attachment.

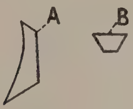

FIG. 731

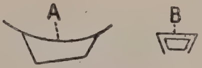

FIG. 732

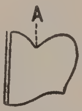

FIG. 733

The key is made of iridio-platinum or platinized gold and filed smooth to form a dovetail as in Fig. 731, A and B. A strip of platinum No. 32 gauge is bent to fit the sides of the key perfectly and filed off even with the face or broad side of the key, and a floor of the same metal fitted to it and soldered with a little pure gold. (Fig. 732, A and B.)

In using this form of abutment the side of the crown to which the key is to be attached should be straight from the gum line to the top of the cusp, and should be reinforced with a piece of No. 28 gauge coin gold soldered across the whole face of the crown. (Figs. 733 and 734.)

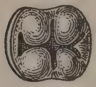
Fig. 734

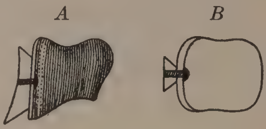

Fig. 735

The key is then put in place, a hole drilled through it and the side of the band, and it is fastened with a small platinum rivet, such as a tooth pin (Fig. 735, *A* and *B*), the under surface of the key, if made of iridio-platinum, having first been covered with pure gold, as the union between iridio-platinum and the solder is not strong. It is then soldered to the cap, using very little solder. (Fig. 736.) The female part of the attachment, or shoe, is then slipped over the key and a thin piece of platinum cut out to slip down over the key next to the crown and this is burnished closely to it. (Fig. 737.) It is then waxed to the shoe, removed, invested, and covered with pure or coin gold (Fig. 738), after which it is trimmed to its proper dimensions, replaced on the crown, the facings ground in, and the bridge constructed. (Fig. 739.) If a saddle is to be used, it is first waxed carefully to the shoe, removed and soldered, after which it is replaced on the model and the bridge constructed as before.

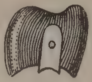
Fig. 736

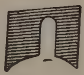
Fig. 737

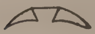
Fig. 738

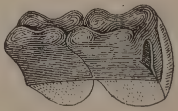
Fig. 739

This form of attachment can be used on vital teeth where there is a large cavity available. The face of the inlay is made straight, the same as the face of a crown to which a key is to be attached. The key is soldered to it and the shoe fitted and connected to the bridge as described above.

For attachments for any of the anterior teeth or for bicuspids, where the teeth are to be cut to or below the gum line, the cap with the tube and split pin will be found to be most generally useful.

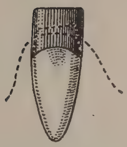

FIG. 740

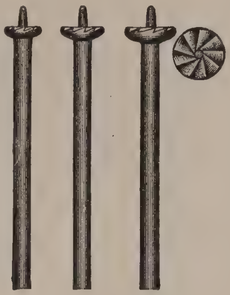

FIG. 741

The root is left standing about $\frac{1}{16}$ inch out of the gum, the band made and fitted in the same way as for a Richmond crown, being carried about $\frac{1}{16}$ inch under the gum (Fig. 740), after which it is removed and the root cut down just below the gum line on the labial side, but not so low as for a Richmond crown, and leaving it high on the palatal or lingual side. For doing this, the Ottolengui root facers (Fig. 741), are best adapted as they will take the root down quickly and evenly and with less mutilation of the gum tissue and consequently less pain to the patient.

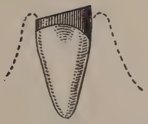

FIG. 742

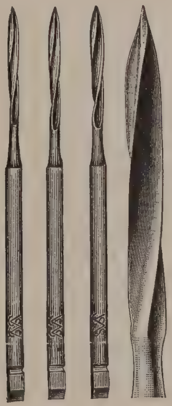

FIG. 743

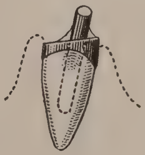

FIG. 744

The band is then cut flush with the top of the root and the floor of coin gold 28 gauge sweated or soldered to it. (Fig. 742.)

In enlarging the canal of a root to receive either a pin or tube, spear-pointed drills or instruments which cut on the end should never be used, as there is danger of perforating the side of the root.

The canal is first opened with broaches, these are followed by Gates-Glidden drills, beginning with the small and working up to the ones and enlarging the canal to within about $\frac{1}{8}$ to $\frac{1}{4}$ inch from the apex. These are followed by the reamers designed by the author which are made in sizes to correspond to the size of the tubes or pins which are to be used. (Fig. 743.) Both these and the Gates-Glidden drills have smooth guide points which will follow a canal, but will not cut on the end, and there is very little danger of perforating a root in using them.

The canal having been enlarged to the proper size, a hole is made in the floor of the cap a third larger than the tube and it is placed on the root, the tube adjusted and waxed to it with sticky wax. (Fig. 744.) It is then removed with the cap, invested and soldered the same as a pin in a Richmond crown.

After it is soldered, the tube is cut off flush with the floor of the cap, the entrance to the tube is countersunk a little so that the split pin will enter readily, and the cap polished, care being used not to round the corners. (Fig. 745.)

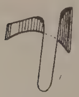
Fig. 745

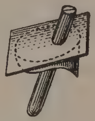
Fig. 746

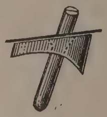
Fig. 747

The cap is then placed on the root and the impression taken and cast made. The subsequent steps are done on the cast.

The floor of the outer cap is made of No. 28 coin gold, a hole being drilled through a piece of proper size for the case so that the pin, which has been previously fitted to the tube, will fit tightly. They are then placed in position on the inner cap (Figs. 746 and 747), waxed together, removed, invested and soldered with a very small piece of 22-carat solder. (Fig. 748.) The pin and floor are then cleansed in acid, replaced on the inner cap and the floor trimmed flush with it all round. (Fig. 749.)

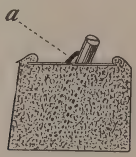

Fig. 748

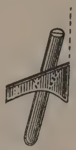
Fig. 749

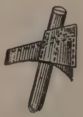
Fig. 750

The half band is of No. 28 coin gold and should extend about half way to the buccal side of the floor as in (Fig. 750). It should extend only to the gum line on the lingual side and should not go below it. It is then waxed to the outer floor, removed, invested and soldered, using a very little 22-carat solder (Figs. 751 and 752), after which the lower edge of the half band is trimmed to follow the gum line and it is ready for the impression. (Fig. 753.)

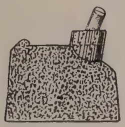

Fig. 751

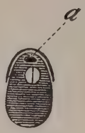

Fig. 752

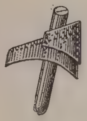

Fig. 753

Another way of making a tube and split pin attachment which is especially useful in cases where the roots stand at such an angle that it is not possible to insert the tubes to a sufficient depth and have them parallel, is to have the split pin attached to the lower or inner cap and the tube embedded in the bridge. Take for example two canine roots in the lower jaw, standing as represented in Fig. 754.

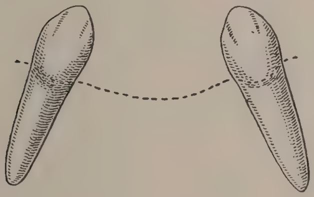

Fig. 754

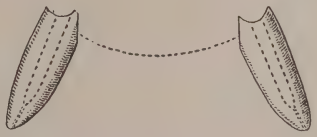

Fig. 755

In a case of this description, the roots are prepared in the same way as when they stand in a normal position, with the exception that the mesial or approximal angle is cut away, in order that the bands may be adjusted with their sides nearly parallel to each other. (Fig. 755.)

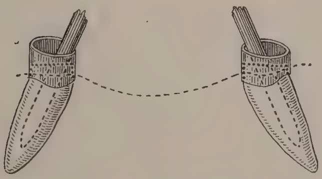

Fig. 756

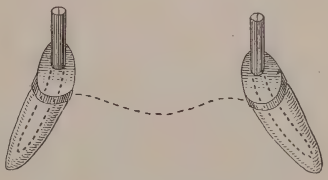

Fig. 757

The bands are then fitted, the roots cut down, the canals enlarged to receive a strong pin, and a plaster impression taken with the bands and pins in position as in Fig. 756. A cast is then made, the bands cut flush with the top of the root and the floor of No. 28 gauge coin gold is sweated to them. An opening is then made through the floor to fit the pins tightly and the pins are bent just beneath the floor so that when they pass through they will be parallel with each other. (Fig. 757.) The pin and floor are then waxed together, invested and soldered from the under side. (Fig. 758.)

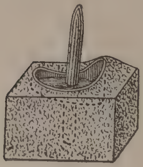
FIG. 758

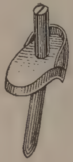
FIG. 759

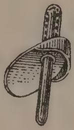
FIG. 760

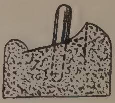
FIG. 761

In making the outer cap, the floor of No. 28 gauge coin gold is drilled so as to fit the pin easily but not loosely. It is then cut flush with the sides of the inner cap and the half band made and soldered to it (Fig. 759), after which it is replaced on the inner cap. The tube is next placed over the pin and is made to set down closely on the floor all around and is waxed to it with hard tough wax. It is then removed, a little investing material carried into the tube and a small iron wire inserted, letting it extend about $\frac{1}{4}$ inch below the floor. (Fig. 760.) This will hold the tube in position and is embedded in the investment, the tube being soldered to the floor with 22-carat solder. (Fig. 761.) The facing is then ground to the floor of this cap (Fig. 762), and when the bridge is invested for soldering, a small iron wire is inserted in the investment to prevent the tube from shifting, the same as when attaching it to the floor. When soldered, the tube is embedded in the solder in the lingual side of the crowns. (Fig. 763.)

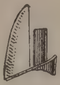
FIG. 762

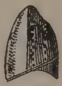
FIG. 763

The abutments which have been described are all known as retaining abutments. By retaining abutment is meant one which holds the bridge firmly in place in the mouth, preventing its shifting or dropping out, such as a telescope cap, tube and split pin, etc.

A supporting abutment is one which supports one end of a bridge, but has nothing to do with retaining the piece in the mouth. A countersunk gold filling or inlay in which a spur rests is an example of this latter style.

Countersunk Supporting Abutments.—A hooked spur resting in a gold inlay or a countersunk gold filling forms a most excellent support for one end of a bridge. This is especially the case in the lower jaw, where it will safely support a bridge of two or three, or even more teeth with but a single retaining abutment. In the upper jaw, with a crown carrying a single pontic, the other end may be supported by the spur and inlay or filling, and it is often useful in furnishing additional support for a larger bridge with more than one retaining abutment.

If any of the six anterior teeth are to be utilized as a support, the spur should come on the lingual side. A notch or a groove is made where the point of the spur is to rest. The supporting abutment cap or caps are put in place and the impression and bite taken and the model prepared. The bridge is constructed in the usual way. A cavity is made in the plaster tooth where the notch or groove indicates the cavity in the tooth is to be. The spur is made of round platinized gold wire of about 14 gauge and is bent in the form of a hook and a second bend, if necessary, to pass into the wax. (Fig. 764.) It is then placed in the anvil and flattened a little with a hammer. This makes it a little thinner sidewise but deeper vertically, thereby rendering it stronger. It is then shaped with a file or small stones about as Fig. 765 and waxed into the end of the bridge, as in Fig. 766, invested, soldered and finished. In the case of a spur resting on a molar where greater strength is required, and where a larger inlay is possible, a dovetail spur may be used (Fig. 767). When the bridge is completed, it is tried in the mouth and then removed and the cavity made in the tooth, clearing the spur underneath and all around leaving a good margin.

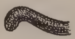
Fig. 764

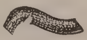
Fig. 765

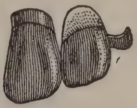
Fig. 766

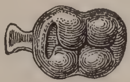
Fig. 767

If it is a fixed bridge, the cavity is filled with inlay wax and properly trimmed. The spur of the bridge is then covered lightly with cocoa butter and the bridge warmed a little, put in position and the patient instructed to close the mouth thus forcing the bridge in place and pressing the spur into the wax inlay.

The bridge is then removed, the excess wax trimmed away and the bridge replaced. This is repeated several times until everything is as it should be, and then the inlay is flasked and cast and after it has been cleansed, it is tried in the mouth and then cemented. After the cement has hardened, any finishing touches needed are given to the inlay and the bridge placed in the mouth. If everything is all right, the bridge is removed and cemented in place.

If the bridge is removable, the cavity is made as described above, and the bridge put in place and worn for a few hours, say from one day to the next. When the patient returns, the bridge is removed and thoroughly cleansed and dried. The inner cap is then put in place in the outer and pink paraffin and wax flowed around the margin of the outer cap where it laps the inner, so that there will be no chance of any cement squeezing in between the two. The bridge is then cemented in place. It should not be removed for an hour or so, or until the cement has thoroughly hardened. The bridge is then removed, the inner cap remaining cemented to the root, and all excess cement cleared away from around the cap, after which it is well to paint the gum with iodin.

The cavity for the spur is now cleaned out, filled with wax, the bridge replaced and the teeth closed together, and the inlay finished and cemented as described above.

In the absence of facilities for casting, gold fillings may be used to support the spurs, although unless the work is done very carefully, it is not as accurate as where the inlays are used.

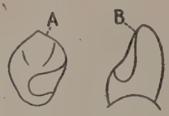

Fig. 768

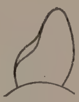

Fig. 769

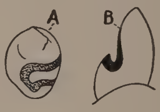

Fig. 770

Where a spur is to rest in a filling in any of the anterior teeth either upper or lower, the cavity is made in the palatal or lingual side of the tooth toward the bridge as in Fig. 768, A and B. Where the bite does not interfere, the cavity is made at the basilar ridge where the enamel is very thick, and should be of good size, approximately about $\frac{1}{8}$ inch in diameter. It is best to start it with a small carborundum wheel, using plenty of water, and cutting through the enamel to give the general outline to the cavity before putting on the rubber dam. The rubber dam having been adjusted, the cavity is deepened with burs as much as possible without endangering the pulp. The cavity is well undercut and a filling of hard gold thoroughly condensed is inserted. It is made large enough so that the contour of the tooth is somewhat exaggerated as in Fig. 769. The filling is then polished and a hole drilled in the center of it on the palatal side to within a short distance of the bottom of the cavity, the base of the hole being shaped with a bud-shaped bur about the size of No. 14 to 16 gauge wire. A groove the same size is then cut from this opening to the distal side of the filling, being careful to leave a strong body of gold underneath so as not to weaken the filling. (Fig. 770, A and B.) A small piece of paraffin and wax is then pressed into the pit and groove in the filling and an impression taken and the model prepared. When it is opened, the wax is removed and it leaves a perfect impression of the cavity and groove. If the wax is not used, the plaster may not reach the bottom of the cavity or if it does, the point will be so fine that it is likely to be broken off.

The spur is made of iridio-platinum or platinized gold wire of No. 14 to 16 gauge, the size depending upon the size of the bridge and the amount of strain to which it will be subjected. The end of the wire is bent, as shown in Figs. 764 and 765, and pointed, leaving it just long enough to rest on the bottom of the hole with the shank resting in the bottom of the groove (Fig. 771) and passing under the cusp of the pontic or to the backing of the facing, should it be one of the six anterior teeth.

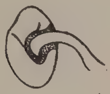

FIG. 771

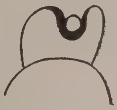

FIG. 772

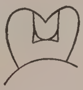

FIG. 773

In the molars or bicuspids, the cavity is made in the crown of the tooth, extending down on the approximal side far enough to allow for the filling and spur. (Fig. 772.) The inside base of the cavity should be made, as far as possible, flat or slightly convex as in Fig. 773. This will make a firm base for the filling and there is little likelihood of the tooth being fractured or split by any pressure that may be brought to bear on it, the shape of the filling having a tendency to bind the crown together and prevent fracturing.

If the cavity is prepared so that the filling or inlay is wedge-shaped, there is a chance of its splitting the tooth, especially the bicuspids, which are not strong on this line.

TUBES AND SPLIT PINS.

The tubes for removable bridgework are made from iridio-platinum plate, No. 32 gauge. A series of polished steel mandrels consisting of six made from the regular sizes of Stubb's steel rods, which can be procured from dealers in machinists' and jewelers' supplies. The gauge numbers (Stubb's) run from 48 to 53, inclusive, the sizes of the rods being, respectively, .075, .072, .069, .066, .063 and .058 of an inch in diameter.

These rods are cut in lengths of from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches and the ends are carefully rounded. For convenience, they are numbered by notching or with rings around one end from one to six, beginning with the smallest, 1, 2, 3, etc., Fig. 774.

The size of the tooth must govern the size of the tube to be used, the smaller size for teeth having small roots and the larger size for the teeth with heavier roots. A strip of No. 32 iridio-platinum plate about $\frac{7}{16}$ inch wide is beveled at the end to a knife edge (Fig. 775); the edge is then turned slightly and rolled around the mandrel, which should be one size smaller than the one which is to be used in finishing the tube. (Fig. 776, 777 and 778.) The mandrel is then removed and the tube soldered with pure gold. (Fig. 779.) The next size larger mandrel is then driven through the tube (Fig. 780), stretching it and making it

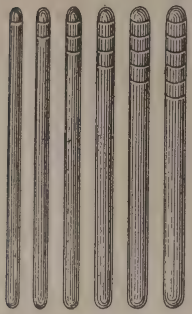

Fig. 774

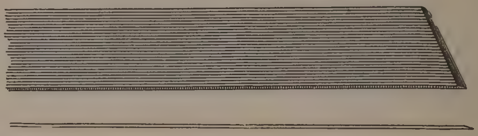

Fig. 775

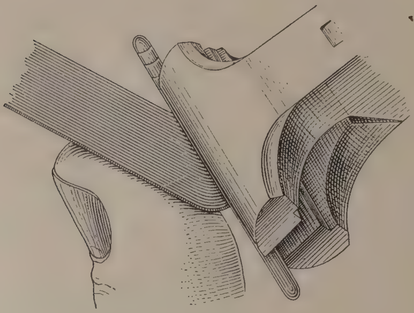

Fig. 776

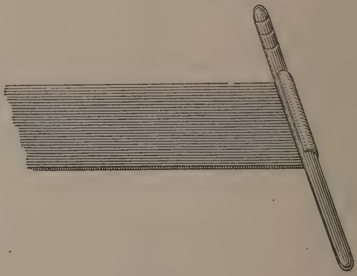

Fig. 777

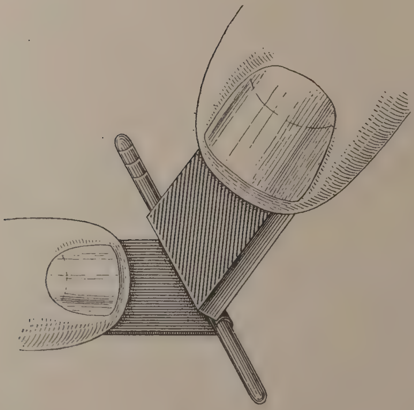

Fig. 778

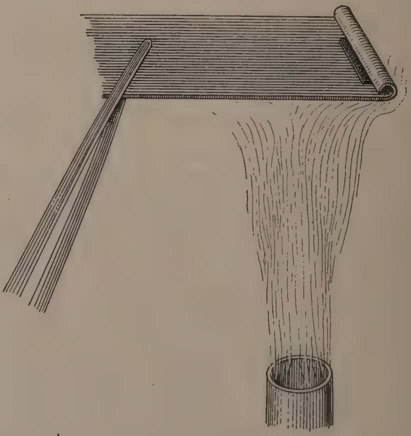

Fig. 779

perfectly smooth and straight on the inside. The surplus plate is now cut away and the lap joint filed even with the rest of the tube. (Fig. 781.)

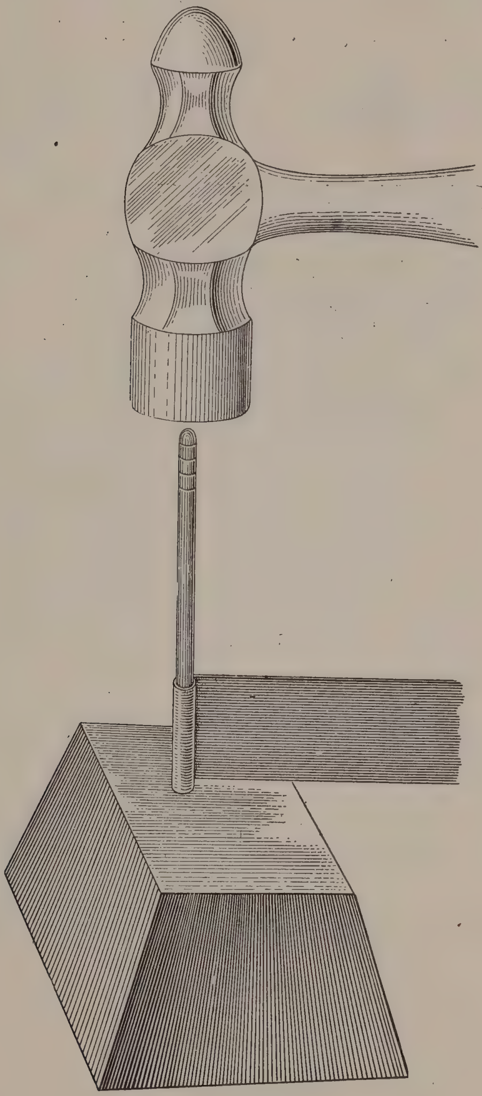

Fig. 780

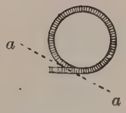

Fig. 781

A floor of the same metal is then soldered to one end of the tube with pure gold and the surplus trimmed away and the end finished with a file. (Fig. 782.)

Split Pins.—In making the split pins for removable work, half-round platinized gold wire is used. A piece of such length that when doubled it will be about $\frac{1}{8}$ inch longer than the tube, is bent at the center and the two flat sides brought in contact for a little more than $\frac{1}{8}$ inch from the open end and soldered just at that point with coin gold. (Fig. 783.)

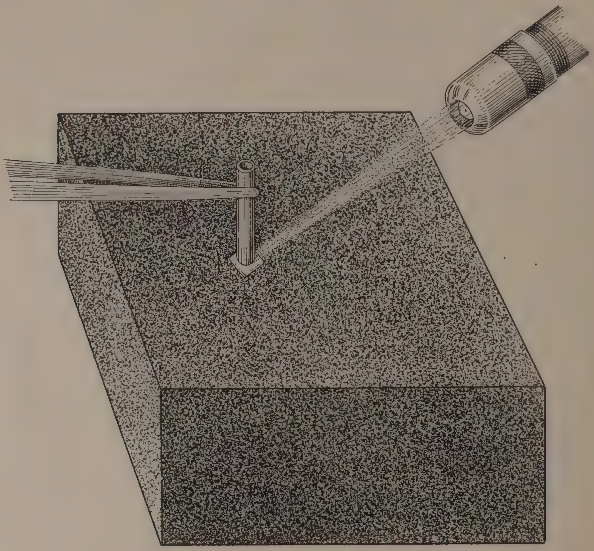

Fig. 782

This end is then grasped in a pin-vise and the sides hammered together on an anvil, bringing the two halves in contact. During the hammering, the pin must be kept rotating, striking lightly, thus forging it round, as the halves are gradually brought into contact. If the two halves are hammered together without rotating, the pin will be flattened and it will be almost impossible to make it round. The pin is now annealed, and filed and burnished to fit the tube.

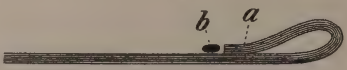

Fig. 783

It requires considerable knack and skill to file a pin properly, and the first one made is not likely to be a work of art.

The pin-vise is a very important consideration for this work. It should be perfectly round and have jaws which will act as a clutch and hold the pin firmly on a line with the pin-vise without moving in the vise. (Fig. 784.)

The file used for roughening down should be a flat, 5 inch, No. 2 cut and should be held in the right hand very lightly, the forefinger resting on the face of the file and over the middle of the pin extending from the pin-vise. (Fig. 785.) The pin rests on a block and the pin-vise is rotated to the right with the thumb and fingers of the left hand. The file is passed lightly over the pin in the opposite direction, using very little pressure, not much more than the weight of the file itself. The file should be moved only while the pin is rotating, touching lightly and lifting it while the pin is still in motion. When the pin has been roughened down to nearly the size desired, the final fitting should be done with the finest file that can be obtained and then burnished. Files which are cut only on one side are indicated for the final fitting. The best ones are those made with a six or an eight cut on one side, the other side being perfectly smooth; if they can be obtained, the eight cuts are preferred. Trim the pin down until it goes fairly snugly into the tube, then using the smooth side, burnishing until the pin will

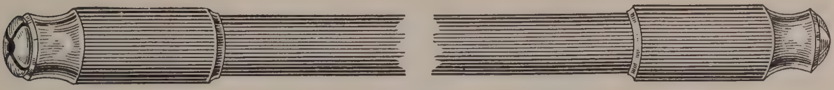

Fig. 784

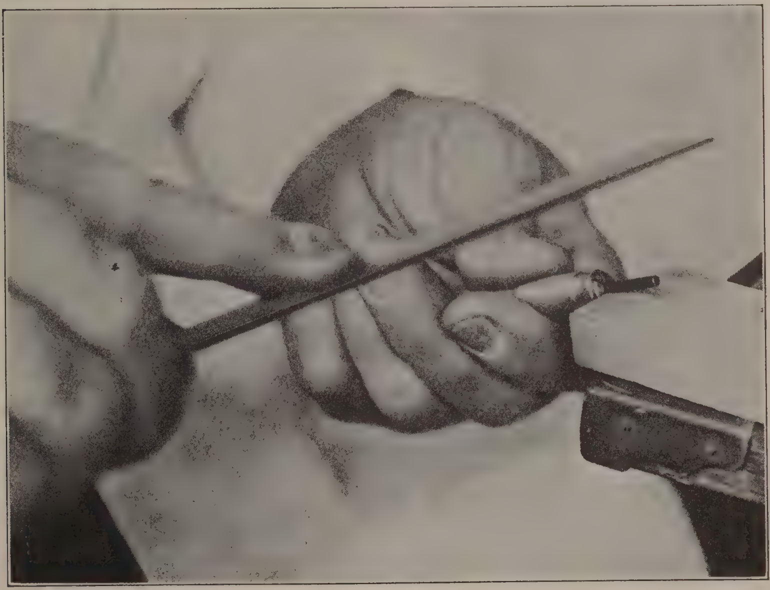

Fig. 785

enter the tube easily, but not loosely. binding slightly its entire length. If it is a very long pin, it is left closed at the end, and to tighten it, a very thin instrument is introduced between the halves, spreading them slightly, thus making a long, slender elliptic spring. (Fig. 786.) If it is to be a short pin, the closed end is cut off with a fine file, filing in the direction of the split and then rounding and burnishing the end so that the fit of the pin to the tube may be tightened by separating the ends of the former with a thin knife-blade. In a split pin made in this way, there is no loss of material and the maximum strength of the metal is maintained.

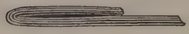
Fig. 786

OTHER ATTACHMENTS FOR REMOVABLE BRIDGEWORK.

There are a number of attachments for removable bridgework on the market, nearly all of them being similar in type and of greater or less value. The following are among the best.

McCollum Attachment.—The *plain* type of the McCollum Attachment (Figs. 787–790) is of a general T-shape as illustrated. It is provided with a cleft at right angles to its transverse portion for adjustment. The male part is made of high-fusing platinized gold, the female, of platinum in the form of a slotted, seamless tube.

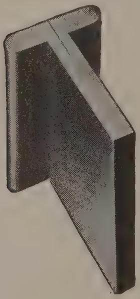
Fig. 787

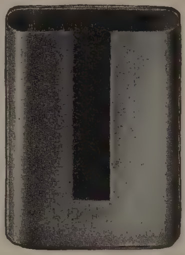
Fig. 788

The *Stress-breaker* extension type has a shank formed of a doubled-over piece of metal, the leaves of which terminate in the two halves of the slide member of the attachment. The split is left for the purpose of expanding the attachment to take up wear. The tube fits over the slide member and is to be soldered to the abutment. The stress breaker box fits loosely over the shank. The denture is to be cast around it, a hole being drilled and threaded piercing the lingual or palatal wall of the box. A set screw is fitted to this hole and rests against the shank of the attachment, holding it in place. It will be seen that in addition to forming a flexible connection between denture and attachment, this construction permits of easy replacement in the event of breakage. All that is necessary in such a case is to release the set screw's retention of the attachment and to insert a new one.

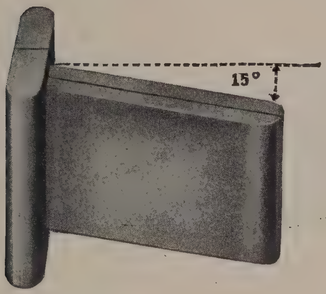

Fig. 789

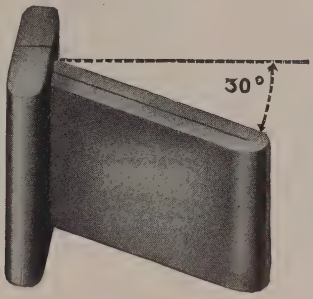

Fig. 790

Forms 2 and 3 McCollum Attachment.—To add to the possibilities of adaptation, particularly in close bite cases, the attachment is also made with the shank offset instead of at right angles to the slide member. No. 2 form carries an extension at a 15 degrees angle, Fig. 789; No. 3 at a 30 degree angle, Fig. 790.

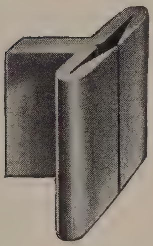

Fig. 791

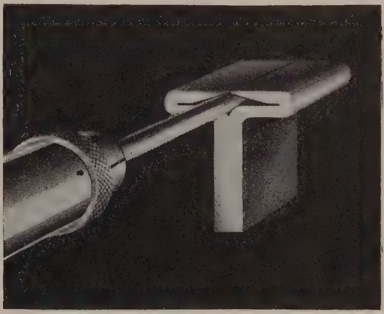

Fig. 792

Stern Attachment.—The Stern adjustable attachment (Figs. 791 and 792) consists of a pair of transverse wings joined to a solid shank. The wings are doubled over, leaving a space in the center which is designed to accommodate a round rod (a common steel needle is most satisfactory) which is inserted for the purpose of increasing the tension on the wings of the attachment when adjustment becomes necessary.

In this manner the adjustment is made with precision and without altering the fit. Various sizes are provided to accommodate different circumstances.

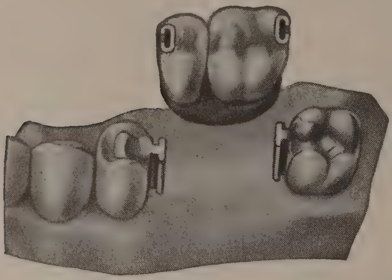

Fig. 793

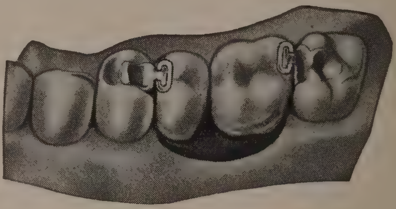

Fig. 794

The Berry Attachment.—The Berry attachment here shown (Figs. 793 and 794) is applicable to a great variety of partial dentures. It is substantially constructed of hard, wear-resisting gold clasp metal and can be adjusted to take up wear by closing the tubular portion slightly.

The post or male part is designed to be soldered to a crown or inlay abutment, the tube to be secured to the denture.

SADDLE BRIDGES.

The most difficult piece of work which the crown and bridge specialist may be called upon to do, is to make a satisfactory extension saddle bridge for the lower jaw restoring the lost molars. A bridge of this kind, if properly made, will prove as satisfactory as any bridge that can be put in the mouth. If it is not properly made and the saddle is not properly adjusted, it will be most unsatisfactory and will ruin the abutments more surely and quickly than any other form of denture which could be inserted. Extension saddles should not be used, except where the teeth have been out for a long time and the process has been well resorbed and the tissues are well hardened. It is rarely that they are indicated until the teeth have been out for a year or more, but occasionally there are exceptions. Bridges of this kind should practically always have at least two anchorages, although there may be at times an exception to this rule, *i. e.*, where the teeth have been out for a number of years and there is a very pronounced ridge and especially if a partial denture has been worn for some time.

As a rule, the abutment caps should be made first. If, for requirements of strength, telescope crowns are to be used, these crowns should be made, united together and articulated. If porcelain crowns are to be used, the inner caps are made, the tubes paralleled and soldered into the caps, and the impression taken with these in place.

The success of an extension saddle bridge depends entirely upon the perfect adaptation of the saddle to the ridge. In getting the impression for the saddle, it is a good plan to first take an impression in modeling composition and, after enlarging it a little so that it will sit farther down on the ridge, to use it as a tray for taking the plaster impression. The plaster is mixed fairly stiff, placed in the composition tray and pressed down firmly over the ridge and held there until it has well hardened. A good impression having been secured, the cast is prepared and should be of sufficient depth so that there will be no chance of the die springing or breaking when swaging the saddle. The outline of the saddle is then marked on the cast and the cast built up a little with wax around the outline as in Fig. 795, so as to turn the edge of the saddle and present a thick rounded edge to the soft tissues. The die and counter-die may be made of zinc and lead or of fusible metal, the latter being preferable because of its lack of contraction.

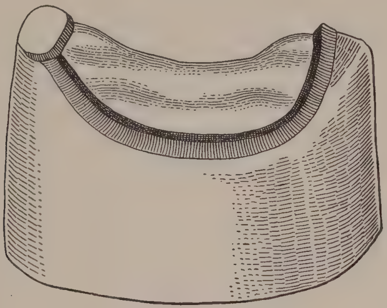

Fig. 795

The saddle is struck up of soft platinum of No. 36 gauge and should be just large enough to allow for the edge being turned up all around. (Fig. 796.) It is then cleansed in acid, the under side painted with whiting to keep the gold from running over it, and also on the upper side along the top of the ridge to within $\frac{1}{8}$ inch of the distal end and at the front where it is turned up to meet the abutment cap. (Fig. 797.)

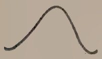

Fig. 796

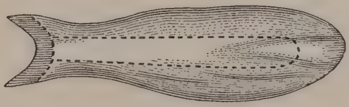

Fig. 797

Coin gold is then flowed over the sides so as to fill them even with the turned up edges of the plate. (Fig. 798.) It is then swaged again with the die and counter-die, cleansed in acid and is ready for adjustment. The inner caps are now placed in position on the roots. The next step is the one upon which the success of this form of denture entirely depends, and that is the one of adjusting the saddle accurately to the alveolar ridge.

The Adjustment of the Saddle to the Ridge.—It will be found when the saddle is placed in the mouth that it is resting on the top of the ridge and has no bearing anywhere else. (Fig. 799.)

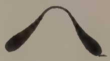

Fig. 798

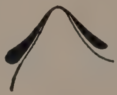

Fig. 799

If this is not remedied, resorption will rapidly take place, allowing the piece to sag and bringing the whole strain on the abutments, with the result that sooner or later the roots will become loosened and lost. The front end of the saddle, which is free from coin, is turned back so that it will clear the abutment caps and it is placed in the mouth, with the forefinger of each hand resting on the sides of the saddle, and rocked from side to side. This will give an idea as to the amount of correction needed. It is then removed, placed on the model, raised a little from it and the sides pressed together slightly, the thumb and fingers grasping the lower edges of the saddle at points *a–a*, Fig. 800. It is then replaced in the mouth and tried again. This is repeated until the saddle rests perfectly solidly without rocking at all and sits comfortably on the ridge when under pressure. If it is found that the sides have been brought together too much, so that it presses too hard at the lower edges, it is pressed down on the model and again adjusted until it fits perfectly.

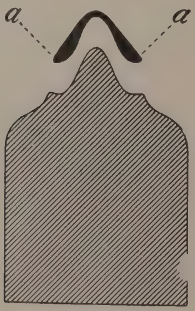

Fig. 800

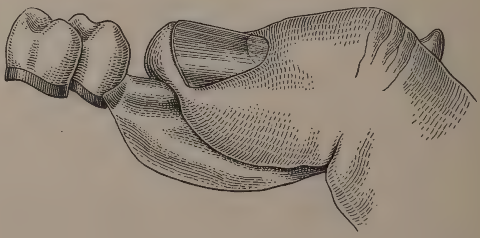

Fig. 801

When it is satisfactorily adjusted, it is held in place under heavy pressure with the thumb or forefinger and it and the abutments covered thickly with plaster, covering the thumb or finger as well, and the saddle held firmly in position. If the saddle is on the left side of the mouth, it is held in place with the thumb of the left hand. (Fig. 801.)

If it is on the right, it is held with the forefinger of the left hand. (Fig. 802.) The plaster is mixed in the same way as for taking an ordinary impression, but more potassium sulphate, or whatever is used to hasten the setting of the plaster, is used, as the plaster for this purpose should set very quickly. After the impression has thoroughly hardened, it is removed and the saddle and caps are carefully replaced in the impression, waxed in position, the inside of the caps also being waxed, and a small cast run.

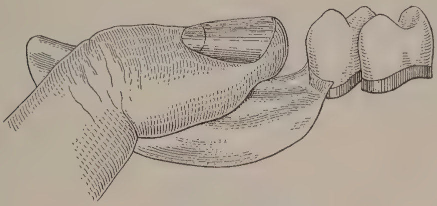

Fig. 802

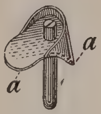

Fig. 803

The inner caps are then removed with warm pliers and the wax cleansed from the caps and model. If porcelain crowns or facings are to be used on the abutment caps, the excess tubing is cut flush with the floor of the caps and the caps finished and the entrance to the tubes countersunk. The outer caps are next made, the split pins fitted and soldered in and the caps united with a 21- or 22-carat solder.

The outer and inner caps are now put together and they, with the saddle, are replaced on the model.

The front end of the saddle, over which no gold has been flowed, is then bent forward and trimmed and fitted so that it just comes in contact with the outer cap, following the lower edge of the half band and part way labially along the floor to *a–a*, Fig. 803. The saddle is then waxed lightly to the caps and a strong iron wire is bent to lay across the floors and along the saddle and this is heavily waxed with hard sticky wax. If telescope crowns are used, the wire should extend over the cusps, down the side of the cap and along the saddle, as shown in Fig. 804, and heavily waxed. This will hold the parts firmly in

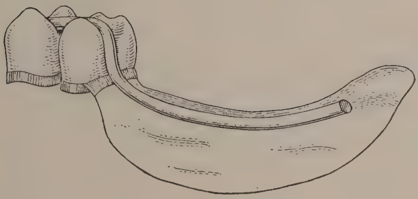

Fig. 804

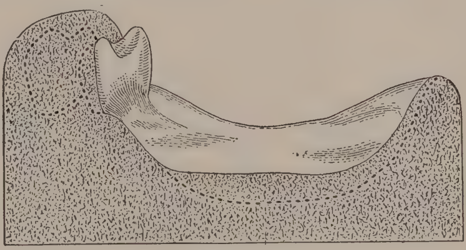

Fig. 805

position and prevent distortion when investing. The inner caps are now removed, and the piece invested, filling the outer caps carefully with investment and letting it come up a little way over the lower edges of the saddle as in Fig. 805. The saddle and caps are united with 21-carat solder, flowing it heavily at the point of contact and over the forward end of the saddle so as to give a strong, rigid attachment. (Fig. 805.) When cool it is removed from the investment.

After cleansing in acid, the caps and saddle are placed in the proper position in the mouth and the articulation taken. This can be in plaster, modeling composition or wax, as it will be attached to the caps and the saddle and will come away with them so that there will be no danger of distorting the articulation when pressing it in position on the cast. The model is then prepared and the bridge constructed.

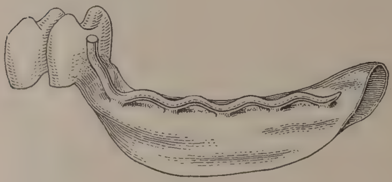

Fig. 806

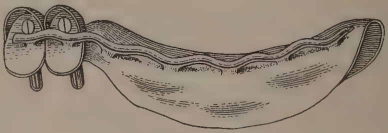

Fig. 807

The bridge can be made with porcelain crowns or facings, using gold occlusal surfaces, or the teeth may be attached with vulcanite. When vulcanite is to be used, a platinized gold wire is soldered to the caps and along the saddle, with 20-carat solder, looping it at intervals, as shown in Figs. 806 and 807, at the same time that the caps are united to the saddle. This will give strength and rigidity to the piece and also form a firm attachment for the vulcanite. The sides of the saddle should be well stippled, and if desired a gold wire can be soldered around the edge of the saddle before uniting to the caps.

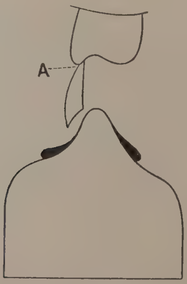

Fig. 808

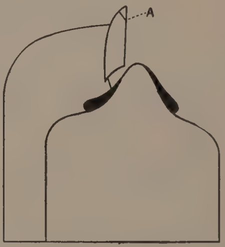

Fig. 809

Where facings are used, it is better that they should not be ground to fit the saddle exactly, but should stand away from it for a little distance (Fig. 808), the object of which will be seen later. The tips of the facings should be high enough to touch the lingual side of the buccal cusps of the upper molars as in Fig. 808, A.

After the facings have been ground they are held in place with wax and a wall of plaster built up on the buccal side so as to retain them in position after the wax has been removed. (Fig. 809.) The facings are then removed and the occlusal ends ground off at an angle of about 45 degrees with the backs or lingual side as in Fig. 809, A, leaving them so that they will clear the occluding teeth by about $\frac{1}{32}$ inch. The facings are then backed with thin platinum or pure gold, the backings touching each other and extending from the beginning of the bevel at the occlusal end to the saddle, which they should touch closely all along. (Fig. 810.) The facings are then waxed firmly to the saddle with hard adhesive wax, the wax being high enough to support and hold the cusps. (Fig. 811.) A solid cusp must be used, the buccal side ground or filed to fit the bevel of the facing and waxed in place. (Fig. 811.)

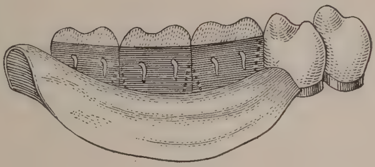

Fig. 810

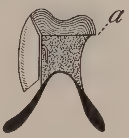

Fig. 811

The buccal and lingual sides are next covered with wax, the pink paraffin and wax being preferable, as it is not sticky and carves nicely. Both sides are then carved to represent the natural gums. This should be done very carefully and the wax made perfectly smooth in order to secure a clean die, so that when the plates are struck up, they will require no finishing other than with pumice and rouge.

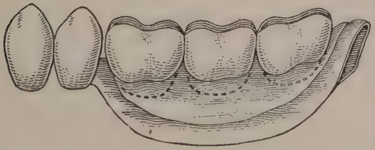

Fig. 812

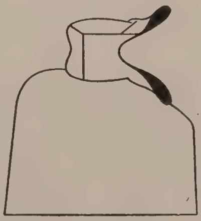

Fig. 813

On the buccal side it should be carried above the lower edge of the facings and well up between them, as in Fig. 812. The carving on the lingual side should correspond in depth and breadth to the facings on the buccal side. On either side, the wax should extend only to within $\frac{1}{8}$ inch or a little less from the lower edge of the saddle.

An impression is then taken of each side separately, carrying the plaster well above the gum line and over the heel on the buccal side, and on the lingual side well above the cusps and below the saddle and far enough over the heel to meet the impression from the buccal side. (Fig. 813.) The impression should be deep enough to serve as a model from which to get good strong dies.

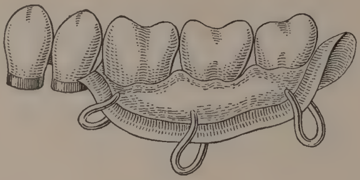

Fig. 814

The dies and counter-dies being made, the buccal plate is struck up from No. 30 gauge coin gold and festooned carefully to fit around the facings. The lingual plate is struck from No. 28 gauge coin gold and fitted carefully, the part going over the heel being brought in contact with that from the buccal side. After they have been cleansed in acid, the buccal plate is placed in position and held with small iron wire clamps, as in Fig. 814. The saddle is then held over a small alcohol flame for a moment to loosen the wax from the plate and the teeth and wax removed and laid carefully aside. (Fig. 815.) The saddle is then invested, lingual side down, only just enough of the investment material being used to keep it from springing. The investment is thoroughly dried out, the piece well fluxed and some pieces of 18-carat solder dropped in between the saddle and the plate. (Fig. 816.) It is then well heated up and when it has reached a red heat, the blowpipe flame is thrown on the under side of the saddle next to the investment and the solder drawn through all around. After it has been allowed to cool, it is cleansed in acid, and the saddle warmed slightly and the teeth pressed back into place until the fitting of the lingual plate shows that they are in their correct position. The bridge is now ready for the final soldering.

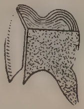

Fig. 815

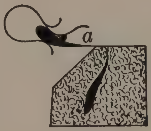

Fig. 816

The piece is invested, buccal side down, the investment on the occlusal side covering about two-thirds of the cusps, and the saddle, to within about $\frac{1}{8}$ inch of the lingual edge. (Fig. 817, *a–a.*)

After the investment has hardened it is warmed a little and the wax lifted out. It is then thoroughly heated up to a light red heat, fluxed and soldered between the cusps with 20-carat solder, the backings being united and connected with the saddle with the same solder, enough being used to give sufficient strength and support to the bridge. (Fig. 818.) Some 18-carat solder is then melted over the lingual side of the saddle and cusps at Fig. 818, *a–a*, and the lingual plate carefully put in place, having been previously fluxed on the inner side. The whole investment is then thoroughly heated to a bright red heat and the flame of the blowpipe passed along the under side of the saddle and the exposed portion of the cusps (Fig. 819, *a* and *b*), until the solder has been drawn through and united the lingual plate all around.

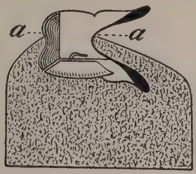

Fig. 817

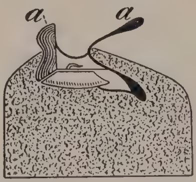

Fig. 818

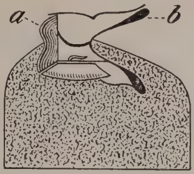

Fig. 819

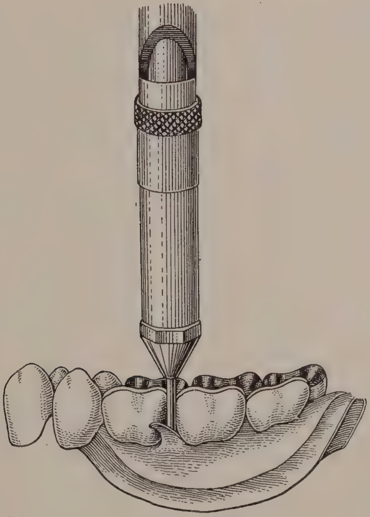

Fig. 820

The greatest care must be exercised in putting on this plate, as it has to be heated so very hot that it is easily burned.

After it has cooled it is removed from the investment, boiled in dilute sulphuric acid, washed in a bicarbonate of soda solution and clear water, and then dipped in alcohol and thoroughly dried. One or two points of the buccal plate which have been carried up between the facings are now bent outward and the space between the plate and the saddle and under the facings is filled with oxyphosphate of zinc. (Fig. 820.) While the cement is yet soft, the points of the plate are pressed back again between the facings. After it has hardened, the cement is cleaned out from between the teeth and plastic gold packed in between the facings and over the points of the buccal plate. The bridge is then ready to articulate and finish.

THE USE OF PORCELAIN CROWNS IN BRIDGEWORK.

With the advent of the casting process came the more general use of all-porcelain crowns for bridgework in place of the veneers which had heretofore been used to partially hide the mass of gold of which the bridge proper was constructed, thus producing much more artistic effects than was possible by the old method.

Any of the crowns of the different manufacturers which come nearest in mold, shade and texture to the requirements of the case can be used. There must be sufficient depth of the bite to allow every crown to have a base deep enough to give strength and stability to the bridge. These bases are preferably cast, although they may be made by swaging and soldering.

The greatest difficulty with which we have to contend in making these bases is due to the contraction of the cast metal on cooling. The result is that the crowns do not fit as they should and more or less cutting, trimming, and fitting is necessary before they will go in place, and not infrequently it is necessary to do the work over again and perhaps not even then will the desired result be attained.

The method has been tried of first burnishing or swaging pure gold over the bases of the crowns and then waxing up and casting over the pure gold. This has perhaps improved matters somewhat, but still it is very rarely that it has been possible to secure anything like a perfectly fitting base, especially if the crowns are of any considerable size, for with the larger castings there is a proportionately greater amount of shrinkage.

Another way of overcoming the difficulty is to build out or enlarge the base of the crown before waxing, in order to make up for the shrinkage of the gold, and while not entirely overcoming the difficulty in every instance, which is probably due to faulty technic, it has, in the majority of cases, reduced the trouble to a minimum.

This method does not do away with the shrinkage of the gold, for that is an inherent property which nothing can overcome, but by it we counteract or make allowance for this contraction of the metal on cooling.

The method of procedure is first to swage or burnish tin-foil, of varying thicknesses, according to the size of the crown, over the base, in reality making a base of the metal, as in Fig. 821. It is then lubricated and the wax base is built over the tin-foil, the lubricated surface allowing its easy removal. The size of the base of the crown has, of course, been increased the amount of the thickness of the tin. We have thus made allowance for the shrinkage, so that when the crown is placed in the casting it fits very closely, and if we have been very careful in our technic, there will be little or no trimming to be done.

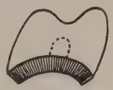
Fig. 821

The thickness of the tin-foil may vary according to the size of the crown, but ordinarily foil 0.005 of an inch will answer for all purposes.

The burnishing of the foil over the bases is very quickly and easily done. The lighter foil can be pressed nearly to place with a piece of soft rubber and the wrinkles at the edges smoothed out with the thumbnail or a piece of orangewood. If using heavier foils a piece of orangewood and a small burnisher are all that is required to secure the close adaptation which is necessary to insure a perfectly fitting base.

In making the bases for a series of crowns for a bridge, it is not advisable to cast them together in one piece, as, if the bridge is of any considerable length, the shrinkage would be proportionately great in that direction, so that it would be necessary to grind the crowns on their approximal surfaces before they would go into position on their bases. This would result in shortening of the bridge and leaving a space between it and the adjoining teeth or abutments. The best way is to cast these bases separately, and in no instance should more than two be cast together. The casting of each base separately and afterward uniting them does away with the shrinkage which would otherwise take place.

The casting of the bases for abutment crowns may be done directly on the caps, or they may be cast separately and afterward soldered to the caps. The latter way is preferable in removable work, as there is less danger of disturbing the accuracy of adjustment between the outer and the inner caps.

The same method of procedure obtains where a saddle is used as an additional support to the abutments and the crowns mounted on this saddle. If there is no great depth between the occluding teeth and the saddles, the crowns are ground so as to leave only sufficient space for the base. (Fig. 822.) The crowns are tinned in the manner described and the wax flowed between the bases and the saddle which has previously been lubricated. They are then carved and removed from the crowns and saddles separately, the sprue wire attached to the lingual side (Figs. 823 and 824) and the bases cast.

They are afterward adjusted in position on the saddle and invested, each piece being held in place by a little wire clamp, the wire passing from the top of the post to the under part of the saddle directly beneath. (Fig. 825.) With the half cap, the clamp extends from the top of the post to the under side of the floor. (Fig. 826.)

The investment should be very light and just fill the under side of the cap or saddle, leaving the whole of the upper parts exposed. This facilitates the thorough heating up of the piece and the solder is easily drawn through from the lingual side, uniting the bases to the saddle or to the cap. The crown side of the bases should be well coated with whiting or some antiflux, so that there will be no danger of the solder flowing over this surface and destroying the fit of the crowns.

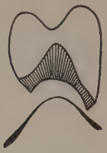
FIG. 822

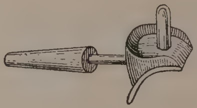
FIG. 823

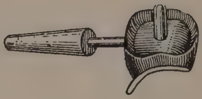
FIG. 824

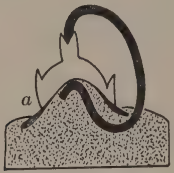

FIG. 825

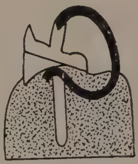
FIG. 826

Saddles.—The saddles are struck up of 36-gauge soft platinum plate and are afterward heavily reinforced by flowing coin gold over the outer surface, after which they are adjusted in the mouth and their relation to the abutments obtained by taking an impression over the abutments and saddle, while the saddle is pressed firmly into the tissues.

Deep Saddle.—Where there has been a considerable amount of resorption and there is a great depth between the occluding teeth and the ridge, it would make these pieces unnecessarily and undesirably heavy to build solid bases extending from the crowns to the saddle. This will apply where there is to be an abutment at each end of the bridge and also in extension saddles which are anchored only at one end, as in the lower jaw where the molars are missing. The lower edges of the crowns are beveled so that the bases may come up over the gingival edge, gripping them tightly, thus affording a firm seat and minimizing the possibility of fracture.

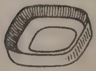
FIG. 827

The bases may be made in the form of a ring, covering the beveled edge and extending just far enough underneath to form a positive seat for the crown, as in Fig. 827. These bases are cast in the usual manner and united to each other. They are then placed in position on the saddle and waxed firmly mesially and distally. (Fig. 828.) The under side of the saddle and abutment caps are filled with investment, and the surplus is placed on the slab and smoothed off, leaving it $\frac{1}{2}$ to $\frac{3}{4}$ inch in depth. The saddle is then settled lightly in the investment, some of which is carried over the middle part of the saddle and over and under the crown base at that point, but not coming near the mesial or distal ends where the bases are to be attached to the abutments and the saddle. (Fig. 829, *a* and *b*.) The inside of the ring bases and the crown base are coated with whiting, and the piece heated up and soldered with 21-carat solder, leaving the connecting rings suspended between these points, as in Fig. 828. The crowns are then placed in position in the bases and the buccal and lingual sides between the bases and saddle filled in with wax, and carved so as to restore the gum contour, leaving nearly $\frac{1}{8}$ inch of the edge of the saddle exposed, and coming about midway on the labial and lingual side of the ring bases. (Fig. 830.) Impressions are then taken of these carved surfaces and models prepared. Dies and counter-dies are made and plates of 28- or 30-gauge coin gold struck up and carefully fitted and adjusted to the saddle. The wax is then removed and the crowns taken from their bases. One of the plates is put in position and held in place with a clamp over the edge of the saddle and the piece placed in the investment, open side down, leaving the side on which the plate is to be soldered exposed, as in Fig. 831. The investment is dried out and the inside of the ring bases coated heavily with whiting or other antiflux. The piece is then well fluxed between the plate and the saddle and

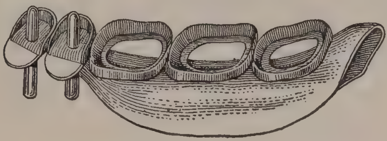

Fig. 828

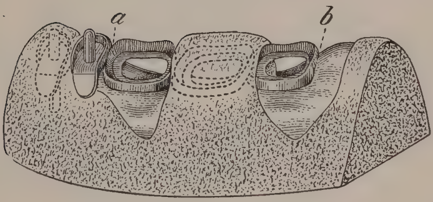

Fig. 829

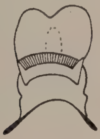

Fig. 830

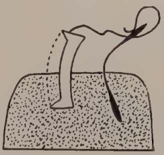

Fig. 831

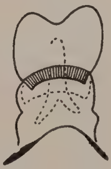

Fig. 832

also between it and the rings, which are thoroughly united with solder, preferably 20-carat.

After it has been removed from the investment, it is cleansed. The plate for the opposite side is then clamped in position and the piece invested and soldered in the same manner as the first. (Fig. 831.)

The object in making a saddle in this way instead of casting what might be called the entire shell, and then uniting it to the saddle, is that in the rolled coin gold plates we have a perfectly dense homogeneous mass that can be easily polished and which takes and retains a very high finish, while the surface of a casting is more or less porous and will not take as high polish. It also is much lighter than it could possibly be made by casting.

The saddle is cleansed in acid and polished and is ready for the crowns. The crowns are fitted with posts which extend through the opening in the bases into the body of the saddle. These posts are cemented into the crowns, the hollow body of the saddle filled with cement, and the crowns put in place and held there under pressure until the cement has hardened. (Fig. 832.) A saddle made in this way presents a most beautiful appearance and does away entirely with the showing of the gold. At the same time we have obtained a maximum amount of strength with a minimum amount of weight.

PORCELAIN CROWN WORK AND BRIDGEWORK.

In discussion of porcelain work many matters present themselves for our consideration. Regarded from a purely esthetic point of view, porcelain is the ideal material of which crowns and bridges should be constructed, but from the practical side other things than appearance must also be considered.

If the restoration of the missing teeth were only made for the purpose of improving the personal appearance of the patient, then porcelain should be used in every case, but this should be a secondary consideration.

The health of the patient, depending as it does to a very great extent on the ability of the masticatory organs to properly perform their functions, demands that the question of utility should be given the first importance.

Porcelain is, of necessity, a very fragile material and where great strength is required, it is wholly unsuitable for use.

A tremendous force is exerted by the jaws and widely varying figures are given as to the exact amount. Dr. G. V. Black[1] has estimated the force exerted in mastication as follows: "For the incisors, the maximum force exerted, one hundred and seventy-five (175) pounds; minimum force, thirty (30) pounds. For the molars, maximum force, two hundred and forty (240) pounds; minimum force, seventy (70) pounds.

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[1] The Dental Cosmos, vol. **37**, p. 474.

Force exerted in masticating tough meats ninety (90) pounds; tender meats, thirty (30) pounds. Hard crusts resist a pressure of two hundred and fifty (250) pounds; hard candy, one hundred (100) pounds."

There is no porcelain body made which can successfully withstand the continuous strain to which a bridge will be subjected.

Undoubtedly, porcelain has its place in crown work and bridgework, but until some method is discovered whereby it can be annealed so as to render it tough and to a certain extent pliable, its uses will be limited to single crowns and bridges on which there will be very little strain.

For single crowns where there is sufficient depth to allow a considerable amount of body being used, porcelain can be employed with good results. Where teeth have been lost and much resorption has taken place, so that there is a great depth between the gum and the occluding teeth of the opposite jaw, porcelain will make a much more artistic piece of work, but it can never be as serviceable as a well made and perfectly articulated gold bodied bridge. If porcelain is used, the work should always be made removable, or it should be set in such a manner that it can be easily removed for repair in case of accident, for such a bridge cannot be repaired in the mouth.

Where an upper or lower artificial denture is worn, a porcelain bridge has a much better chance of a long period of usefulness than where it occludes with the natural teeth, for the force exerted in mastication is very much less where an artificial denture is used.

In all cases where porcelain is used, the bulk of body must be as great as it is possible to make it. It should never be placed in thin layers over bands or any of the attachments or metal work of the crown or bridge. Sooner or later the porcelain is sure to flake off, exposing the platinum, rendering the piece unsightly and leaving sharp ragged edges of porcelain to cut and irritate the soft tissues.

If the root of a tooth which is to be crowned sits inside of the arch, so as to necessitate the setting of the facing beyond the labial side of the cap, it should be carried far enough over to allow placing a thick rope of porcelain over the band, which should be well stippled in order to give a mechanical hold for the body.

CHAPTER XVII.

THE HYGIENIC RELATIONS AND CARE OF ARTIFICIAL DENTURES.

By ALFRED C. FONES, D.D.S.

Dentistry has at last reached that point in her progress where the thinking element of the profession recognizes the great importance of mouth cleanliness, and the fact that operative and prosthetic work must be constructed with an understanding of the anatomy and histology of the tissues of the teeth and jaws. Up to the present time, dentistry's greatest field of effort has been the restoration of tooth structure lost through dental caries or through the infection and destruction of the pericementum. Concentration upon the use of metals and other materials to secure tooth restorations or dentures approximating the normal has developed a body of men highly skilled in the finer mechanics. The demand for this high grade of mechanical skill will always endure, but the hygienic relationship of these restorations to the underlying and approximating tissues must be taught and understood, in order that dental surgery may be a true surgery and that these mechanical constructions may be true blessings.

Although for many years the microscope has been revealing the cells and structures of tissues, dental histology, as a science, is of comparatively recent date. Much has now been unfolded to us that was previously obscure, until today we know, with a reasonable degree of accuracy, the origin, function and final accomplishment of the different cells which form the teeth and their supporting tissues. We also know the essential factors which govern the health and activity of the cells, and it is the deviation from these health factors that has aided us in our investigation of the causes of disease. If the dental profession has erred in an honest endeavor to help humanity by inserting artificial substitutes for teeth which have been lost, and these substitutes have proved to be unsanitary and harmful, it is due to the fact that too much thought has been given to the mechanical construction of the work, and not enough to the influence of the constructed work on the live tissues to which it is attached, or with which it is in contact. The loss of a tooth is much to be deplored, but it is far better that the resulting space should exist, especially if it is in the back of the mouth, than that two other teeth should be mortally wounded to aid in the support of an unhygienic bridge or appliance. By mortally wounded or injured we mean the extensive cutting away of good tooth structure in a vital tooth which will eventually endanger the life of the pulp, or the application of a shell crown, or band that will create an irritation in the subgingival space which is conducive to a pericemental infection.

It is not the intention, in this chapter, to deal with the scientific construction of prosthetic dentistry, but attention cannot too frequently be called to the dangers of injuring a healthy, vital tooth in an effort to substitute one or more that may be missing.

THREE FACTORS FOR HYGIENIC CONSTRUCTION.

In the consideration of the hygienic relations of partial artificial dentures, there are three factors to be carefully considered:

First: In the construction of an unremovable piece there must be no surface that may hold food debris which cannot be readily removed with the toothbrush and floss silk.

Second: The placing of ill-fitting bands, crowns, clasps or partial dentures around the necks of the teeth means, eventually, the resorption of the gingival tissues, and the establishment of a point of ingress for bacteria through the pericementum.

Third: The wilful destruction of live pulps, and the failure to make an aseptic and perfect root operation will permit and invite an apical infection.

Factor No. 1.—Knowing that bacterial digestion of food is quite similar to that of the action of the unorganized ferments in the animal organism, the question arises, is it especially harmful to have a certain amount of food debris decomposing in the mouth? If the quantity of such food was comparatively small and the foods and the bacteria could be thoroughly disposed of at the end of what would be a normal digestive process, we would say no, but such is hardly the case. In the efforts of the bacteria to secure carbon and nitrogen, their digestive process proceeds beyond the point where food is absorbable in the human intestines and we find end-products being formed, especially among the nitrogenous compounds, which are irritating and poisonous. These products, in combination with the toxins produced by the millions of bacteria which have been thriving upon these media, constitute an intake into the gastro-intestinal tract that is not wholesome. Food debris is conducive to large numbers of bacteria, and large numbers of bacteria are harmful. The obtaining of pure milk is but an effort on the part of the scientific dairy men to keep the numbers of bacteria in it at the lowest possible count. What may be considered as pure milk would give a count of 10,000 to the cubic centimeter and what would be unwholesome or dangerous to drink would contain 50,000 to the cubic centimeter. This same principle obtains in the mouth; a reasonable number of bacteria in the mouth is harmless, but if conditions are favorable for the propagation of large numbers to be swallowed at each meal, as well as between meals, the results will eventually be harmful.

Fixed Bridges.—An unremovable bridge with a saddle or flattened surface next to the gum tissue which permits the lodgment of food becomes not only a breeding ground for millions upon millions of bacteria but is a depressant and a source of irritation and inflammation to the mucous membrane and tissues directly underlying it. Such an inflamed surface can readily absorb the toxins generated and the bacteria themselves would not find any great difficulty in gaining ingress into the tissues and even into the lymphatics. Knowing the unhygienic relationship of any type of construction which permits the retention of food debris and the multiplication of bacteria, no unremovable piece should be so constructed that it cannot be kept clean on all surfaces by the use of the toothbrush and floss silk.

There has been considerable discussion as to whether the use of any fixed bridge is advisable. One of the principal arguments against it has been that the teeth used as abutments are fastened rigidly together and are not permitted to function independently. This produces an unnatural stress on the pericementum, creating sufficient irritation to endanger the vitality and life of the tissue. This is undoubtedly true where faulty occlusion exists between the set piece and the opposing teeth. Clinical experience has shown, however, that it is possible to construct fixed bridges which will give good service for many years. In any case where a fixed bridge is desirable, the two important factors for durability are hygienic construction, especially by the use of flush-joint retaining abutments, and an occlusion which permits of the equalizing of the stress of mastication as far as possible.

Factor No. 2.—Artificial Appliances in Relation to Pericemental Tissues.—Histological examination of the mucous membrane which covers the gum tissue shows a dead, toughened, squamous epithelium quite similar to that of the skin which acts as an armor or protection to the underlying tissues. When coarse foods are eaten, as by the carnivora, or where artificial stimulation is produced through gum brushing, a marked thickening or toughening of this membrane may be noted. In the subgingival space, however, this tough epithelial protection is absent and we find the nucleated cells directly on the surface with no covering or protection. The attachment of the soft tissues to the tooth at this point is of a delicate character and may be irritated or wounded if unduly abused. Noyes has traced the lymphatic vessels, as they travel from the gingiva down through the fibers of the pericementum, which may be carriers of bacteria, if opportunity is offered for their ingress by the mechanical irritation of poorly fitting dental appliances. The human organism, in a state of health and normal construction, is very well safeguarded against the ingress of bacteria into the circulatory system. The skin, if kept clean, wholesome, and unbroken, is an excellent protection. The mucous membrane of the nose and throat and of the intestinal tract, if normal and kept clean, affords ample protection against an undue bacterial invasion. And so it would be in the normal mouth if the teeth were kept clean and the gums and mucous membrane healthy, but unfortunately many mouths are not kept clean and wholesome. Therefore it should be clearly understood that any prosthetic piece which depends upon some appliance in contact with a tooth to stabilize it, or lock it into place, must not have such means of attachment extending deep enough into the subgingival space to injure these delicate tissues, nor should a crown or band form a shelf or recess that will permit the retention of food debris, to not only destroy these supporting tissues but to be a possible source of local or systemic infection.

Cast Gold Crowns.—If it is deemed necessary to use a cast gold crown over a molar tooth with a live pulp, every precaution should be taken to see that, after grinding and shaping the tooth to secure walls parallel with the neck of the tooth, the exposed tubules are protected against any possible future action of bacteria.

The writer has found that by placing rubber dam on such prepared teeth, and after thoroughly dehydrating them, he may paint two or three coats of a mixture of nitrate of silver and alloy, which will form a deposit all over the surface of sufficient thickness to act as a protection to the living substance in the dentin for many years. This mixture is made by crushing a crystal of nitrate of silver on a glass slab and pouring over the powder an equal amount of finely ground Standard Alloy. Sufficient water is added to give the mixture the consistency of thin cream, and with a small cotton swab wound on the end of a stiff broach this black mixture is painted over all surfaces of the tooth, allowed to dry, the surface wiped off with a piece of dry cotton and again painted, the process being repeated two or three times.

Clasps.—In the construction of clasps for partial dentures, the methods employed for cast work have now made it possible to secure a perfect fit of the tooth so that there is no encroachment upon the gum tissue. It is highly desirable that a stop be used in connection with each clasp to firmly hold the clasp in position and to prevent the possibility of any encroachment on the gum tissue. Much blame has been placed on the clasp as a device favorable to the destruction of tooth structure. In such cases the clasp has been at fault chiefly as a means of assisting in the retention of food debris against the tooth surface, and the possessor of the artificial denture either failed to appreciate the necessity of, or willfully neglected, a thorough cleansing of the teeth after meals and a brushing and cleansing of the removable appliance. Clasps with stops, if carefully made and kept clean, are hygienic and are one of the best means of retention for artificial dentures that have yet been presented to us. Ill fitting clasps in unkempt mouths are almost sure to destroy the teeth with which they come in contact.

It is questionable if any metal is as harmless as, or is the equal of, clasp gold metal for the making of these attachments. Following is the opinion of the late Charles J. Essig on the use of silver or other metals for clasps:

"It has been observed that clasps exert an influence upon teeth varying in degree according to the condition of the oral fluids and the kind of metal of which they are made. Silver clasps have been found to exert a much more disintegrating influence than those made of gold. Dentures with clasps made of platinum or iridioplatinum act more injuriously than the same appliance fitted with gold clasps. These differences in the effects of the metals upon the teeth are probably due to a galvanic current between the tooth structure and the metal forming the plate, aided by certain conditions of the oral fluids. Silver and platinum should not be used in the formation of clasps, nor indeed for any purposes which demands contact with tooth structure. It has been observed that teeth in contact with a platinum wire employed as a means of retention, their positions having been changed in the correction of irregularities, exhibited erosions in a comparatively short time after its application.

"An example of the action of silver upon the natural teeth was observed a number of years ago in the case of a man who had, in an election fracas, sustained a severe fracture of the jaw. When he presented himself for treatment at the college clinic, nearly a year after the injury had been received, it was found that the jaw was in three parts, no union having taken place. He had received a blow from some heavy instrument upon the mental portion of the bone; the fractures were on each side between the first and second bicuspids. The individual, for some reason best known to himself, had been obliged to remain in concealment for several weeks after the injury, during which time he received no surgical treatment whatever. The appearance of the lower part of the face was greatly changed by the displacement of the disunited parts of the jaw and mastication was impossible. As a temporary or palliative remedy for the latter difficulty, a dental surgeon had fitted a bar of stout, half round silver wire entirely around the lower teeth so as to hold the parts in juxtaposition and restore the articulation of the teeth. The individual had not worn the fixture many weeks before the posterior surfaces of the second molars, where the brunt of the force was borne, became unbearably sensitive. An examination showed deep groves in these teeth, rapidly approaching the pulps. As the neighboring teeth appeared of good quality and entirely free from caries, the abrasion on the second molars was probably due to galvanic action between the silver support and the tooth structure."

Factor No. 3.—Pulp Hygiene.—Every practitioner who is a student of the science of dentistry appreciates the importance of keeping the pulps of teeth alive and healthy, where possible, in each and every tooth. A carious tooth, no matter how slightly decayed, is a tooth wounded and although we may successfully restore such a tooth to a sound and healthy state by operative procedure, it is questionable, in most cases, whether it is good dentistry to deliberately destroy a pulp for the attachment of a bridge or partial plate, or even to cut extensively into a sound tooth for the insertion of an inlay for the same purpose. With our present-day knowledge of apical infections, pulp hygiene becomes the most serious consideration in the prevention of the most dangerous type of dental pathological condition, and he who endangers the life of the pulps of the abutting teeth for the retention of a denture is making an unnecessary sacrifice in order to produce a fine piece of mechanical art.

Removable Bridges.—The advent of the removable bridge, especially one of simple construction, has afforded a very practical means of restoring missing teeth while preserving the integrity of the remaining teeth. Reference is made to the removable clasp bridge which has the advantage of affording independent movement in function, pulp conservation and is quite simple in construction. From the standpoint of hygiene the removable bridge is unquestionably most desirable and offers every facility for cleanliness and comfort.

Gold and Vulcanite Dentures.—Although thousands of full or partial vulcanite dentures are worn with utmost comfort and the mucous membrane retains a fair state of health, it is nevertheless true that the tissues take more kindly to a gold denture. The gold, being non-porous and smooth, is cleaner and metal conducts the heat away from the tissues as it should normally escape. These factors, combined with the comfort of a much thinner construction than is possible with vulcanite, especially in the roof of the mouth, give gold the preference. In fact it may be stated that where teeth are to be replaced on both sides of either jaw, the trend of opinion seems to favor the partial gold denture with clasps. Such an appliance is most hygienic and requires the minimum amount of tooth preparation for its retention.

In adapting a partial denture to the gum tissues, care should be taken to trim the denture back from the necks of the teeth to a sufficient distance that the gingivæ are free from any pressure from the denture. The supporting tissues, such as the alveolar process and pericementum of many good teeth, have been injured and destroyed by the irritation and pressure created by dentures lying over the gingival borders and close to the necks of the teeth.

After a vulcanite denture is worn for some time, especially if it has been poorly vulcanized, it absorbs considerable food débris, and if it is not kept scrupulously clean by a thorough scrubbing with brush, soap and water, it will have a pronounced sour odor. In such unkempt mouths the mucous membrane becomes swollen and irritated by the products of decomposing food and the immense numbers of bacteria kept in constant contact with it. The rubber is a non-conductor and does not readily permit the conduction of heat from the tissues, and this in turn becomes a source of irritation. Every individual who wears a vulcanite denture should be instructed to buy, at the drug store, a brush that is designed to clean these dentures, and should be impressed with the necessity of cleansing the denture and the mouth after each meal. If a plate brush cannot be secured, a good stiff toothbrush will answer the purpose. At least once a week the denture should be placed in a glass of water and one-half of a teaspoonful of aqua ammonia be dropped into the water and stirred up, and the denture allowed to soak in the solution at least for one-half hour. This strong alkali will saponify and thus assist in the removal of the food débris that may be retained in the pores of the vulcanite, and after thorough brushing and scrubbing with soap and luke warm water, it will be found that any odor that may have been present will have disappeared and the denture will be sweet and clean. Patients should be warned against the use of hot water on vulcanite, as dentures have been ruined in this manner.

Removal of Dentures During Sleep.—A very important point to consider is the wearing of artificial dentures during sleep. Many people do not take kindly to the thought of removing partial dentures, especially when they are first inserted. Without question the mouth would be benefited by the removal of the denture at night in order to rest the tissues with which the material comes in contact, giving them a period of release from the abnormal work and stress. Pressure, however slight, has a tendency to create resorption in the human body, and the removal of the denture at night tends to lessen this slow process of resorption about one-third. It is well known that conditions are more favorable to decay during sleep on account of the lack of motion of the saliva and fluids of the mouth around the teeth during this period of rest, and if the partial denture is worn at night, not only should the denture and teeth be thoroughly cleansed but the inside of the clasps should be wiped with a cloth, or better stilll, rubbed with an orange-wood stick and pumice and the tooth surface where the clasp rests given a vigorous rubbing with a piece of flat floss. This care of the inside surfaces of the clasps and the adjoining tooth structure should be a daily procedure irrespective of whether the denture is worn at night or not. Pride may be a reason for wearing a partial denture at night, but there all argument ends. People wearing full dentures soon find themselves more comfortable in resting the mouth overnight by removing the dentures, although it is frequently advisable to wear a new denture constantly for the first two weeks in order to accustom oneself to the artificial substitute. When dentures are removed overnight it will be noted that they do not fit as well for a short period when first inserted in the morning. This is due to a slight recovery or seeming thickening of the gum tissue which has been compressed by the pressure of the denture while being worn.

Rubber Sore Mouth.—For years in the past, there has been a great deal of discussion over the danger of using coloring matter which contains mercury in combination with the rubber, as it was believed that free salts of mercury could be liberated from rubber so treated and that it was the cause not only of sore mouths, but of systemic disturbances. At the present day this subject excites but little interest, yet at times it still crops out occasionally. We know of no better presentation of the subject than that offered by Dr. E. C. Kirk in the

American System of Dentistry, and therefore quote a portion of his article relative to it.

"As nearly all the vulcanizable rubber used in the construction of artificial dentures is of the red variety, which owes its color to mercuric sulphide or vermilion, many have looked upon it as the sole cause of the annoying condition under consideration. Many cases in practice tend to a confirmation of this idea, yet a careful analysis of them, as well as the absence of conclusive evidence based upon systematic scientific investigation, fails as yet to establish the truth of such a theory. The conclusion has been jumped at that as vermilion is a salt of mercury, its action must necessarily be poisonous. That such is not the case is evident from the fact that it is wholly inert medicinally, and is one of the most insoluble of the mercurial salts. With the exception of a strong solution of sodium sulphide there is no menstruum that will dissolve it which will represent a solution of mercuric sulphide, and it is only decomposable by heat or the strong mineral acids. It has been asserted that under the conditions to which it has been subjected in producing a dental plate, decomposition of the vermilion sometimes takes place, resulting in the liberation upon the surface and throughout the texture of the plate of metallic mercury, which, being acted upon by the oral fluids, produces local mercurial poisoning. While it may be possible that individual samples have been shown to contain free metallic mercury, a study of all the conditions would preclude, theoretically at least, the possibility of such a general occurrence of it as to account for the frequency of rubber sore mouth. The temperature to which the vermilion is subjected during vulcanization is far below that necessary to effect its decomposition, and even should the proper temperature be reached accidentally, the presence of sulphur incorported with the material in great excess, which is necessary to effect the hardening of the rubber, would immediately reconvert into mercuric sulphide any mercury which had been set free."

Dr. G. V. Black asserts that the sore mouth produced by artificial dentures is due to the growth of certain fungi, the Streptococcus magnus, Streptococcus continuosum, etc., which elaborate an acid secretion that acts as an irritant to the mucous membrane and causes the condition. He finds these fungi upon the surface of all dentures, without regard to the material of which they are constructed, but in greatest number upon the surfaces of vulcanite dentures; which he attributes to the fact that the irregularities and roughnesses of the surfaces of such dentures afford lodging places where they rapidly develop, because the denture cannot be as readily kept clean. He regards absolute cleanliness as a complete protection from inflammation.

It is possible for an artificial denture of even the most hygienic construction to prove a menace to the wearer unless definite instruction is given in the daily care of the appliance. The following outline of the home care of artificial dentures is suggested to supplement the

Battersea Public Library.

instruction given in the office, and a printed copy should be supplied with every removable appliance.

THE HOME CARE OF ARTIFICIAL DENTURES.

General Care of any Removable Appliance.

1. Remove the appliance after each meal, and scrub with a stiff brush, soap and water.
2. Clasps or other attachments must be rubbed vigorously once a day with orangewood stick and pumice, especially the surface in contact with the natural teeth.
3. After the brushing and flossing of the natural teeth, the tooth surfaces upon which clasps or other attachments rest must be rubbed vigorously with flat floss or linen tape.
4. Any appliance should always be removed at night to rest the tissues, prevent undue resorption, and decay of the natural teeth.
5. Every six months, the appliance should be cleansed at a dental office to retain the smooth, highly polished surface.

SPECIAL CARE OF VULCANITE DENTURES.

1. Hot water is injurious to vulcanite; use warm water for cleaning.
2. Vulcanite is slightly porous and absorbs food débris, which gives a sour odor to the denture. To avoid this condition, the denture should be placed, once a week, in a glass of water to which one-half teaspoonful of aqua ammonia has been added. When the denture has been soaked in this solution for a half hour to an hour, scrub with soap and water.

CHAPTER XVIII.

CLEFT-PALATE PROSTHESIS.

By EDWIN H. MAUK, D.D.S.

CLEFT-PALATE AND HARELIP.

The colloquial terms "cleft-palate" and "harelip," and among the French, "pike mouth," are commonly used to designate two conditions of oral deformity which are of the same class, and due to the same causes, differing only in degree. Both of these conditions may exist simultaneously, or either condition may be present without the other, but their etiology, diagnosis and prognosis are always considered together in texts on the subject.

Cleft-palate may be defined as a lack of continuity of the roof of the mouth throughout the whole or a part of its length, in the form of a fissure extending antero-posteriorly (Fig. 833).

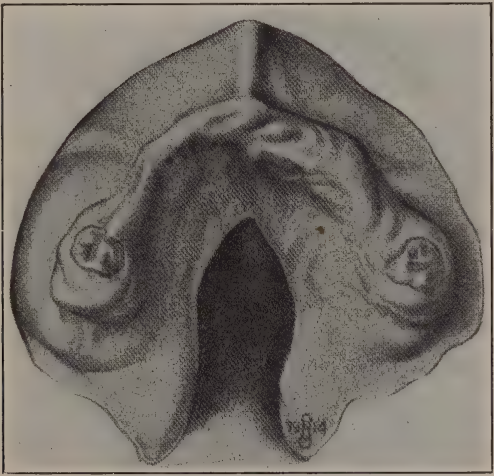

Fig. 833.—Extensive congenital cleft of both hard and soft palate. From a drawing. (Federspiel.)

Palate defects are usually classified as: (1) Congenital (*malformation*) and (2) acquired (*disease* or *accident*). It is common practice to differentiate these also by referring to congenital defects as clefts, and to the acquired as perforations, except in extreme cases where they assume the proportions and position of a fissure. The position and shape of palate defects have considerable diagnostic value. The congenital cleft involves and usually follows the median line as a fissure, while the acquired perforation, if small, is not so likely to occur in the median line (Fig. 834), and if large enough to involve the central portion, is usually of an irregular rounded outline.

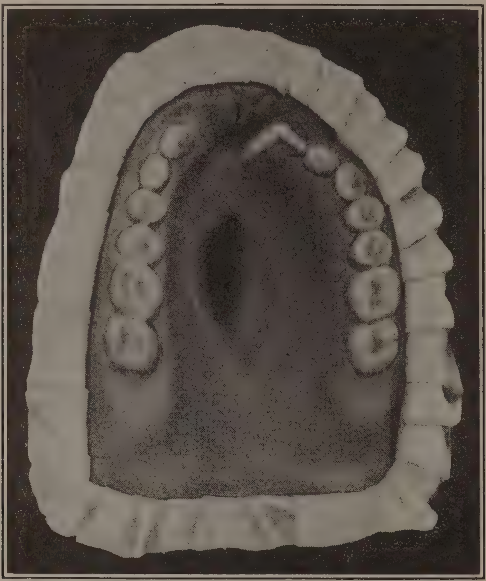

FIG. 834.—Perforation of the hard palate, luetic. (Zinsser and Stein.)

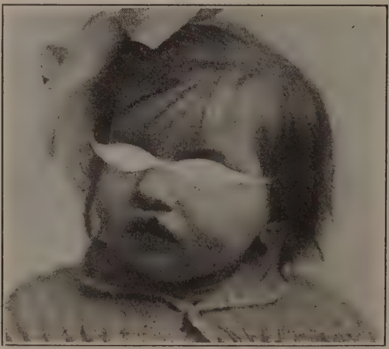

FIG. 835.—Single harelip, mild form. Slight defect without cleft-palate. (Brown.)

Harelip is a lack of continuity of the upper lip varying in form and extent from a mere notch in the border (Fig. 835), to a complete fissure (unilateral) (Fig. 836), or two complete fissures (bilateral), extending into the nostrils and through the alveolar ridge (Fig. 837). It is always congenital, though accidental injury may produce a similar condition. Very rarely a fissure of the lower lip analogous to harelip is observed, and may be attributed to the same causes. Slight defects in the form of harelip often exist without the presence of any palate defect, though the extreme conditions of unilateral and bilateral lip fissure are usually associated with congenital cleft-palate. A case has been noted in which a complete fissure extending into the alveolar ridge was present in the lip without any palate defect[1] (Fig. 838).

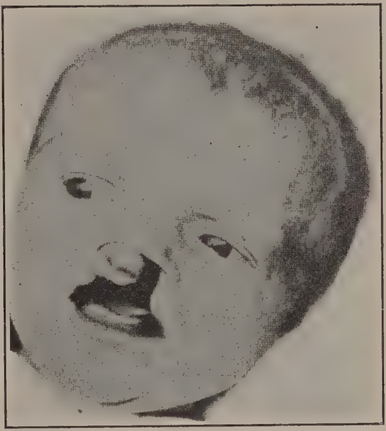

Fig. 836.—Single harelip and alveolar cleft. (Federspiel.)

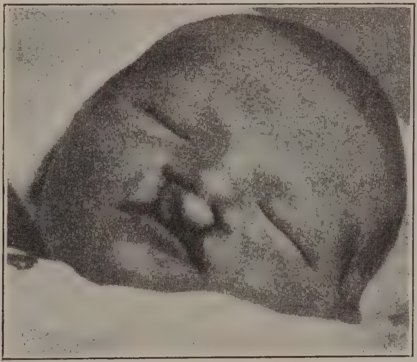

Fig. 837.—Double harelip, usually complicated with cleft-palate. (Brown.)

Etiology.—Failure of the parts to unite during the period of gestation is the accepted reason for cleft-palate and harelip. This is attributed to abnormal or deficient cell activity of the fetus. The reasons for such abnormal or deficient cell function are more obscure. Brown mentions heredity, faulty metabolism (including deficient endocrins), position *in utero* and malformation or pathology of the female genitalia.[1]

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[1] Brown: Oral Diseases and Malformations, 3d ed., Philadelphia, Lea & Febiger, p. 610.

Warnekros advances the novel theory that the exciting cause is the invariable presence of one or more supernumerary teeth which are always found in the lines of fissure. In confirmation of this theory he cites the observation of a large number of cases in which were found the supernumerary teeth, as indicated above.[2]

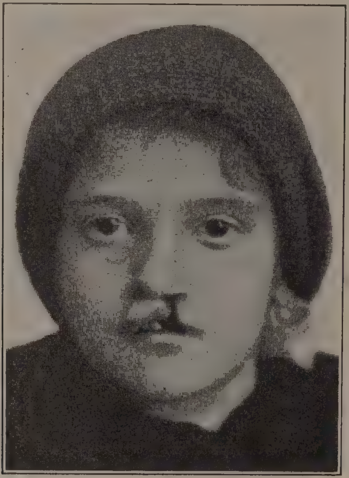

Fig. 838.—Unilateral fissure of alveolar ridge and lip, without cleft palate. (Brown.)

The finding of these supernumerary teeth is in accord with the observations of Brown. He points to the many evidences of "unequal cell distribution" in the individual of this type as shown by other asymmetrical developments accompanying palate defects, such as supernumerary fingers, total congenital deafness, defective function of nutritive organs and a strong neurotic tendency. He concludes that arrest of development in this region is due to the same causes as in other parts of the body.[3]

Acquired palatal defects are almost invariably one of the sequelæ of syphilis, though cases of this kind have been observed in which destruction of the palate was due to other diseases.[4]

More or less extensive perforation of the palate may remain after surgical removal of malignant growths or other tumors in this region. Modern surgery is usually able to eliminate these by plastic operations.

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[1] Oral Diseases and Malformations, p. 577.

[2] Ash's Quarterly, April, 1909, p. 163.

[3] Brown: Oral Diseases and Malformations, 3d ed., Philadelphia, Lea & Febiger, p. 580.

[4] Ibid.

The *extent* and severity of cleft-palate vary greatly. Fissure of the soft palate only may be the sole defect present, or the same condition may be accompanied by a partial fissure of the lip. Next in severity occurs partial or complete fissure of the soft and hard palate and of the lip, sometimes separately (Figs. 837 and 838), but usually in conjunction (Fig. 839). In the extreme cases complete separation of the hard palate exists (or even a double separation, divided by the

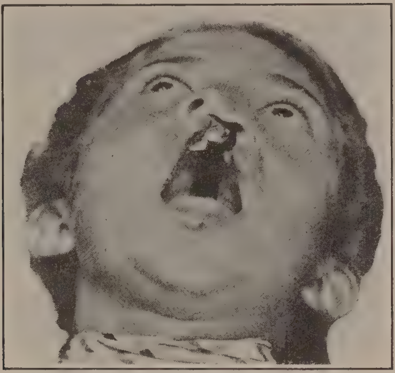

Fig. 839.—Complete cleft palate and unilateral harelip. (Federspiel.)

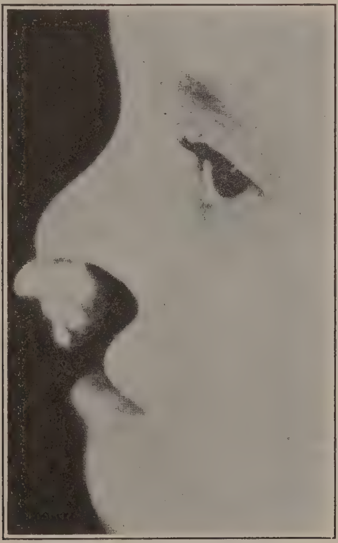

Fig. 840.—Complete double harelip and cleft-palate, showing protrusion of intermaxillary bones and lip fragment. (Federspiel.)

vomer) in conjunction with complete unilateral or bilateral fissure of the lip and intermaxillary bones. Such cases present extreme deformity; the appearance is hideous and repulsive. In the last-named form the intermaxillary bones and the lip fragment protrude and appear suspended from the tip of the nose (Fig. 840), whose alæ are tremendously spread, so that human semblance is nearly destroyed in some cases.

Probably no other deformity can be productive of greater shock and distress to parents nor offer less hope of a useful existence for the child thus afflicted unless corrected, and for this reason it may be said that no other deformity is more worthy of the surgeons' utmost skill and deepest desire to confer a benefit.

Comparable Prognosis: Surgery vs. Prosthetic Restoration.—For correction of acquired palatal defects of any extent, there is usually but the one method possible, namely, prosthesis.

In the congenital cases there is often a choice to be made of two methods of procedure—surgery to eliminate the defect, or a prosthetic appliance to compensate for it.

Each has its advantages and inherent limitations, and the choice more frequently depends upon the age at which the patient presents, surgery being the method almost invariably indicated in early childhood.

Practically all operators agree that palate surgery should be done in early childhood, but opinions vary as to the exact age most desirable. Some advocate a radical and, if possible, complete operation within three months after birth; others prefer to institute corrective measures within the first year, designed by pressure to reduce the space and to mold the bones to a more favorable shape for the final operation, or series of operations, to be undertaken any time within the first few years of infant life.

Surgery.—*Advantages.*—If successful, surgery is permanent in its results, the defect is actually eliminated, and the united bones are covered by tissues continuous with and of the same character as adjoining parts of the oral cavity; therefore, no problem of oral hygiene is involved as with an appliance of any sort.

There is greater probability of normal speech after a successful surgical operation than as a result of an appliance, especially if closure of the cleft has been completed before speech has become fully established. The improvement in speech may not be so marked, nor may it result so soon as is often the case with a prosthetic appliance, but is likely to be more complete ultimately through development of the muscles. In other words, speech development after surgery is not subject to the limitations imposed by any apparatus, no matter how perfect.

There seems to be a consensus of opinion that for cases presenting in early life, and up to maturity, the results to be secured by surgical treatment are far better than may be attained by prosthesis, and that the possibilities of surgery should be exhausted first.

Another consideration is also involved: The malposition of teeth almost invariably accompanying cleft-palate, or ensuing as an unavoidable result of the necessary surgery, demands orthodontic treatment which must be undertaken during childhood and adolescence if its success is to be assured. Happily there are few cleft-palate cases that do not yield to surgery at this time of life.

Surgery.—*Disadvantages.*—Among these may be enumerated the necessity for a hospital operation, involving a general anesthetic, and the well-known and widespread prejudice against both.

Cleft-palate surgery produces no benefit to defective masticating function in adults. When it is undertaken during the first few years of infancy there is almost certain injury to developing deciduous tooth follicles, resulting in their destruction or malposition, and almost equal danger of similar injury to the permanent teeth (Fig. 841). This is especially true in the incisor, cuspid and bicuspid region.[1] On the whole, it may be said that the merits of surgery decrease as the age of the patient increases.

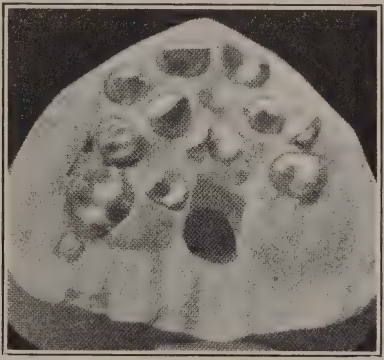

Fig. 841.—Malposed and missing teeth with undeveloped maxillæ. Attributed to trauma in passing silver wires through the jaw in infant operation for repair of cleft-palate. (Federspiel.)

Expense.—While this factor should not be allowed to prevent the attainment of the ideal result, it must be considered. Hospital fees, together with surgeons' fees, especially for a series of operations, usually constitute an initial cost much greater than for a prosthetic appliance. When repairs to the appliance, renewals and probably remodeling in the course of time are considered, the total cost of prosthesis may readily approach or exceed that of surgery. Moreover, there are many children's clinics, endowed beds in hospitals and other charitable agencies established to provide surgical treatment and care for the young indigent.

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[1] Brown: Oral Diseases and Malformations, 3d ed., Philadelphia, Lea & Febiger, p. 584. Federspiel: Int. Jour. Orthodont., 1918, p. 505.

On the other hand, very few clinics exist having either facilities or operators trained to palate prosthesis, and these, as a rule, do not receive the support of the charitable agencies.

Prosthesis.—*Advantages.*—Palate prosthesis for either congenital or acquired defects may be undertaken at practically any age, a successful case being recorded for a child aged four years, in which surgery had not proven successful,[1] thus showing that it is feasible to make artificial palates even before the permanent teeth are erupted. Ottolengui, in reporting this case, states, however, that the "coöperation of the patient being of such importance, especially where lessons in articulation are to be given, it is best to wait until the fifth or sixth year."

Indeed in adult life, and in many cases where surgery has not produced the desired result, it is often the only recourse.

No loss of time from business or employment other than office visits is entailed, as would be the case with a term in hospital. Both the hospital and the anesthetic complications are avoided.

For adults with cleft-palate the prosthetic appliance is usually combined with a partial or full denture, which is almost invariably needed. Thus a distinct benefit in masticating function is conferred.

If the first appliance is not a success it can readily be modified or remodeled with slight inconvenience to the patient, whereas surgery is more or less final in its results, or if successive operations are needed the hospital and anesthetic complications are unavoidable with each one.

Prosthesis.—*Disadvantages.*—With all palate appliances there is the necessity for constant care to preserve a degree of cleanliness, and to avoid unpleasant odor and taste.

With those of the soft rubber velum type, frequent renewal is necessary. With all types there is liability to breakage, with consequent need for repairs, all more or less annoying and inconvenient in depriving the patient of the use of the appliance. Perhaps loss of valuable time may be involved through enforced absence from business or employment due to interference with restored speech, which may be impossible without the appliance.

If the appliance is retained by some of the teeth, more or less injury to them is inevitable in time through erosion, abrasion and abnormal stress, and the ultimate loss of the teeth concerned in retaining the plate is to be expected.

If the patient, either child or adult, has developed an imperfect speech, a new muscular coördination must be acquired. With an imperfect palate, the effort to reproduce the sounds made by others results in an abnormal use of throat muscles which becomes habitual, so that the old habit must first be broken before the patient can readily learn to talk.

This constitutes a forceful argument for the early use of an appliance, if one must be resorted to, since the less firmly fixed such a habit is by reason of tender age, the less will the patient have to overcome, and since youth is the age of adaptability, the more readily will the new habit be acquired.

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[1] Ottolengui: American System of Prosthetic Dentistry, 4th ed., 1913, p. 804.

Again, even though a certain proficiency of speech which makes the patient readily understood may be acquired with the aid of a prosthetic appliance, it is likely that some sounds will never be perfectly produced. In addition, a certain lack of resonance in the tone of the voice will often be apparent, which in itself marks the individual's speech as "peculiar."

Since a prosthetic appliance in some form is often the only recourse, some of the disadvantages enumerated cannot be urged against its trial. They are mentioned merely as inherent defects or limitations which the patient must expect, and of which he should be fully informed, so that hopes impossible of fulfilment will not be entertained.

Neglected Cases.—While it seems to be generally conceded that surgery will greatly benefit, if not entirely correct, palate defects if undertaken early enough, and that its possibilities should be fully utilized, even if necessary to supplement it with a prosthesis later, cases which are neglected past infancy, perhaps to adolescence or young maturity, present a different problem.

The fact that the developing bones have become more or less rigid and unyielding, often makes it impossible to bring about their union. Often the best result that may be expected is a bridge of soft tissue over the cleft, if it be an extensive one. This is apt to be tense and unyielding, so that subsequent bone development, muscular action and muscle development in this region induced by attempts at speech all tend to rupture it, and may cause a recurrence of the cleft. Frequently in a final resort to an appliance it becomes necessary to sever this false roof and trim away cicatricial tissue, in order to make it possible for the appliance to be worn. Thus the work of the prosthetist is made more difficult, and the probability of his success greatly lessened. Taking these factors into account, it is a serious question whether surgery for cleft-palate ought to be undertaken after early childhood.

Prosthesis with all its disadvantages may best be resorted to at once in these cases. The teeth having been erupted are favorable to the retention of the appliance, and the condition of defective or missing teeth often accompanying palate defects renders the use of some appliance necessary in any event.

Cases with small clefts and an abundance of soft tissue may present such favorable conditions as to indicate the choice of surgery even in adult life. Many adult cases, of course, can only be benefited by prosthesis, except for closure of the harelip if present.

These are general considerations, for it is obvious that no hard-and-fast rule may be established.

In no case should the choice be made without most careful and thorough consideration of all factors, both by the surgeon and the prosthetist also if possible.

Types of Appliances.—There are two distinct types of apparatus for closing cleft-palate—the artificial velum (Figs. 842 and 843) and the obturator (Fig. 844), differing both in the details of construction and in the manner in which they operate.

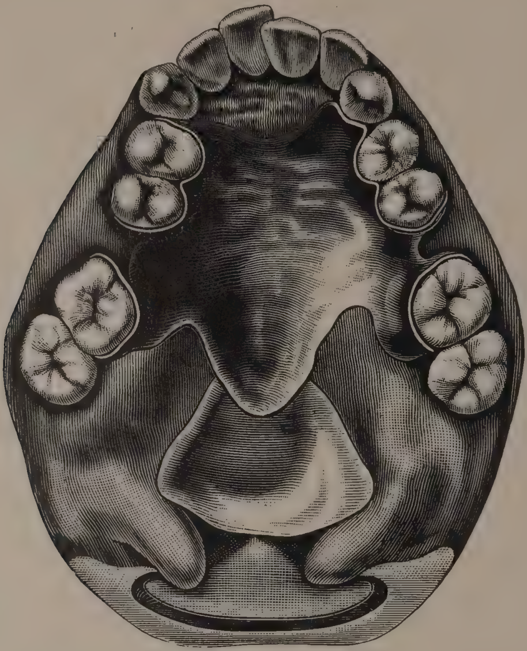

Fig. 842.—Velum retained by plate. (Ottolengui.)

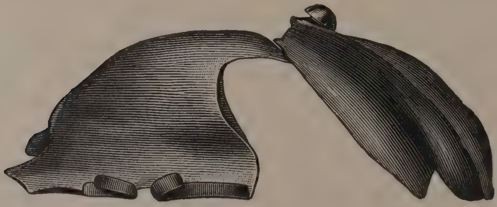

Fig. 843.—Velum and plate, lateral view. (Ottolengui.)

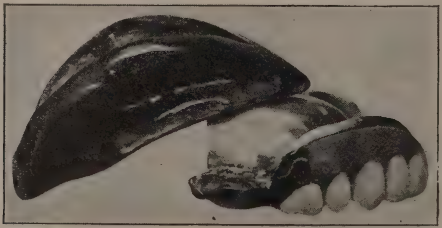

Fig. 844.—An obturator and plate made in separate units and assembled. (McGehee.)

The *obturator* (Lat. *obturare*, to stop up) is an inflexible plug, or cover; a stopper to fill the opening, inelastic and held stationary in its place by the artificial denture, of which it may be either an attached or integral part. It is usually made of vulcanite, and hollow for lightness, and is by its nature adapted to closure of both hard and soft palate clefts.[1]

The *artificial velum* (Lat. *velum*, a veil) is, as the name implies, a flexible substitute for the movable soft palate. It is made of soft rubber and acts as a valve, under the control of and moving with the muscles, to perform the function of closing the air passages as required in speech and deglutition. It is not suited for use in perforations or clefts of the hard palate.

The obturator in its present form is the result of the development of efforts to plug openings in the palate, principally those of acquired origin. Gradually these efforts were extended to the correction of congenital defects. These early attempts were among the first instances of such mechanisms being applied to the mouth, and may be traced back in history to a remote period. The first recorded description of such an appliance was by Ambrose Paré in 1541.[2]

The invention of the artificial velum is quite recent and is credited by Kingsley[3] to Delabarre, about 1810, for a case of *acquired* origin. Kingsley also mentions an artificial velum made by Snell (1823) as the first recorded attempt to close a *congenital* cleft-palate with an appliance.[4] But to Kingsley himself undoubtedly belongs the credit for developing the artificial velum idea and making the device in a practical form.

Materials.—While it may be said that anything which will close the palate opening, even a wad of cotton or a piece of sponge, is in effect an obturator, the more modern appliances depend for their success and durability on more permanent materials. Patients frequently resort to a plug of cotton or gauze for an acquired perforation, even of a considerable extent, and some of the early mechanisms depended on a piece of sponge to close the opening, the sponge in turn being held in place on an artificial denture by means of a metal clip.

Metal construction of the obturator was later developed, for which the alloys of gold then in use for artificial dentures would naturally be utilized. When hard rubber or vulcanite was introduced (about 1850) its advantages for this purpose, its lightness and ease of molding, were so apparent that it is now generally used for the obturator to the exclusion of the other materials, although the metal obturator together with the metal denture, possesses some advantages in resonance.[5]

The development of the artificial velum is even more closely linked with the advent of vulcanized rubber, since no suitable material for it existed prior to that time. Delabarre's velum of "gomme élastisque" (india-rubber) and Snell's velum of the same material must have been very unsatisfactory, sticky and perishable articles without the familiar qualities imparted to soft rubber, as it is known today, by the use of sulphur. This in itself would be sufficient reason for the fact that little use was made of the idea until Kingsley utilized it. Having at his command the new material, soft vulcanizable rubber, made it possible for him to devise appliances not only successful in function but having a certain degree of durability and comparative ease of renewal, both of these features being most essential in determining the serviceability of the appliance.

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[1] Kingsley: Oral Deformities, 1880, p. 214.

[2] Ibid., p. 215.

[3] Ibid., p. 259.

[4] Ibid., p. 261.

[5] Ibid., p. 247.

Indications for Use of the Two Types.—While the artificial velum is by its nature restricted to use for clefts of the soft palate only, the obturator may also be put to the same use, sometimes with equally as good or better results, and is the only recourse for closure of the hard palate cleft. When combined with an artificial velum that part of the supporting plate covering or filling the fissure in the hard palate constitutes the obturator.

The conditions governing the choice of velum or obturator are concisely set forth in the conclusions quoted below,[1] which seem to be borne out by the experience of most workers and writers in this field:[2]

"1. That in most cases of congenital defects the patient will acquire correct articulation more easily and more certainly with an elastic velum than with any other form of apparatus.

"2. That in a majority of cases of the like defect a patient will never acquire distinct articulation with an obturator.

"3. That where a patient has overcome the difficulty by wearing an artificial velum until clear and distinct articulation has been acquired, he may exchange the velum for an obturator and continue to articulate properly."

The decision as to the type of appliance to be applied in a given case for the best results involves: (1) A thorough knowledge of the normal anatomy of the missing or defective parts, and their function; (2) the intelligent comprehension of not only the principles upon which vela and obturators are constructed, but also the manner in which they operate; (3) the case history which will bring out such facts as the patient's age, the nature of the defect (whether acquired or congenital), operations if any, the time of the operation and the circumstances surrounding it making for its success or failure.

Functions.—The *hard palate,* composed of the bony structure and the soft tissues overlying it, serves a dual purpose, namely, that of forming the floor of the nasal cavity and the roof of the oral cavity, and plays a large part in the tone of speech by its shape or curvature and qualities of resonance.

The *soft palate* or natural velum is composed of the uvula (itself sometimes referred to as the soft palate) and the muscular layers of tissue which extend from the posterior border of the hard palate backward and downward until they join the sides of the throat to form the pillars of the fauces. It has great mobility, imparted by its muscle fibers, and may be likened to a curtain hung in the junction of two passages, and capable of changing its position at will to close one passage entirely, leaving the other free. It performs several important functions:

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[1] Kingsley: Oral Deformities, 1880, p. 239.

[2] Ottolengui: American Text-book of Prosthetic Dentistry, 4th ed., 1913, p. 789.

1. To close the nasal passage in the act of deglutition, to prevent food from passing into the nares; also in coughing.

2. In speech it also closes the nasal passages in the formation of many sounds which would otherwise have a nasal resonance if the column of air escaped into or through the nares. In fact it would be impossible to produce such articulate sounds in a form recognizable as speech without this function. In both of the foregoing the posterior wall of the pharynx rises and moves forward, forming a rounded ridge to meet the velum, which is at the same time drawn upward and backward to make its contact with the posterior wall of the pharynx (Fig. 845). In speech this act forces the vibrating air column through the mouth only, and the resultant sound is made clear and distinct, with a quality of tone otherwise impossible.

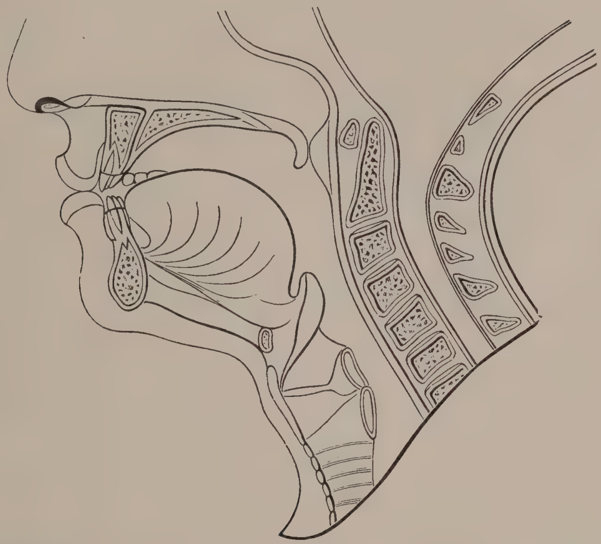

FIG. 845.—Nasal passage closed by contact of soft palate and posterior wall of pharynx. (Brown.)

3. To form a tense low arch meeting the posterior part of the tongue when that organ is drawn upward, thus closing the oral passage, and leaving the nasal passage free. This function is utilized when retaining liquid or air in the mouth while continuing to breathe

through the nose, and is essential in the formation of certain sounds, g, as in go, ng, k, for instance (Fig. 846).

A cleft in the palate, therefore, deprives the patient of the ability to cut off communication between the oral and nasal cavities, thus interfering with deglutition, and rendering this organ of speech so defective as to be incapable of producing a large number of the sounds most essential to speech.

From the above it will be seen that, in order to produce the sounds which the cleft prevented, any substitute must: (1) Afford means to close the nasal passage definitely and with sufficient completeness to interrupt and direct the column of air set in vibration in the larynx, as it issues from the throat; and (2) restore the normal arch or vault of the hard palate to give resonance to the tone thus produced. This last function is that of the appliance covering the roof of the mouth and carrying the obturator or velum, and for this purpose a metal denture is to be preferred.

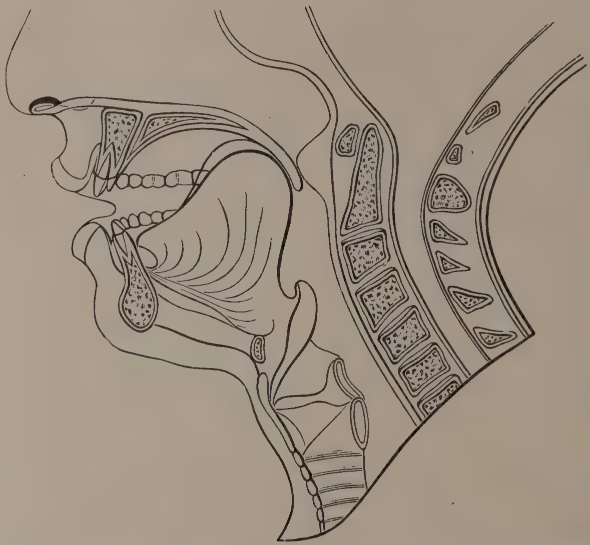

FIG. 846.—Tongue and palate in contact in formation of consonant sounds of g, ng, k. (Brown.)

The first function is performed by either the obturator or the artificial velum, but their methods of operation are radically different.

The *obturator* in its true form, that is, rigidly attached to the denture, merely provides a plug thick enough to stop the gap between the defective parts of the soft palate and long enough so that the posterior wall of the pharynx can come in contact with it.

In repose it may not entirely fill the gap, but in speech or deglutition the muscles of the soft palate cause the divided parts to come into contact with and to slide along its sides, which are purposely made wide enough so that the parts cannot slip off, either above or below.

Thus, between the action of a normal pharynx working against its end and the action of the defective soft palate working against its sides, occlusion of the posterior nares at the will of the patient is assured, which is the first and most essential requisite to speech restoration. Therefore it may be said that while the obturator performs no natural function within itself, it acts as a compensating adjunct to enable the defective parts to function.

The *artificial velum*, on the contrary, is so designed that it assumes the function of the missing part which it replaces, and in conformity with this principle, its essential features are flexibility and elasticity, in order that it may act as nearly as possible in the same manner as does a normal soft palate.

The thin septum with which the gap is bridged is supplemented by flaps or lips at the sides forming a pronounced longitudinal groove, in which the divided soft tissues lie, and in the active state actually grasp the instrument, moving it as they move, and altering the curvature of its surface as occasion demands. The posterior border, also being thin and flexible, conforms itself to the pharyngeal wall, curling slightly at the edge when the two are brought into contact.

On the whole, much less muscular activity is required in the use of the velum than the obturator, which no doubt is the principal factor in the more ready acquirement of speech with it. Then as the muscles become developed and are under more definite control, the obturator serves the purpose.

The principal object sought in making an artificial palate is either acquirement of speech or the improvement of defective speech. Therefore, since it has been shown that the artificial velum functions more naturally than the obturator, offers less resistance to the muscles, in fact, moves with them, and permits more rapid acquirement of speech, it is evident that it is the appliance indicated for the majority of cases in the beginning.

These advantages are sufficient to offset the greater difficulties involved in its construction and its lack of permanency, and the substitution of the obturator later is always possible. With this in mind, Dr. Case designed what he termed a velum-obturator, made first of soft rubber and later replaced with hard rubber in the same form, which will be described in succeeding pages. Dr. Ottolengui also reports the successful use of the same type of appliance.

Training and Environment.—The success of an appliance in speech is dependent on several factors other than its fit and its adaptability to the case. Among these may be mentioned the following:

Age.—The age of the patient, children being more adaptable, as a rule, than adults, though possessing less determination in wearing an appliance which causes even temporary inconvenience.

Mentality.—The intelligence of the patient, together with keenness of observation of others in their manner of speech, will contribute largely to the success attained. The patient's ambition also, if aroused, will foster the determination necessary, and reinforce his perseverance.

Environment.—Since imitation is essential to the acquirement of speech, it is extremely important that the patient have an environment in which he hears good speech, clearly enunciated. Trained singers are apt to be free from careless habits of pronunciation, such as slurring or omission of word endings, and to have well-defined consonant sounds, which are the most difficult for the cleft-palate patient.

Training.—Given all the above favorable conditions, specific and systematic training, except in the rarest instances, is still an indispensable and essential feature. So important is training considered that Makuen states[1] that "Training will do more for the improvement of speech than will the operation (for cleft-palate). A patient who can have the advantage of but one of the two procedures can probably be given better speech by the training alone than by the operation alone."

Dr. V. P. Blair, of St. Louis, has the following to say regarding "cleft-palate speech" and "speech training:"

"When a person has learned to speak with a cleft in the velum, even after the most perfect operation, there will remain the stigma of the 'cleft-palate' speech, which is due to the escape of air through the nasopharynx during the effort at producing sounds that require its closure. This is due to two causes: The cleft velum is shorter than the normal velum, and this defect is seldom remedied by the operation; further, the patient who has learned to speak with a cleft velum must be educated to the proper use of the newly reconstructed one. In some cases in the presence of a cleft, by diligent effort, the patient will develop the use of the superior constrictor muscle to an ultra-normal degree. Such persons will give the best postoperative results, both on account of the muscular control that has been acquired and because the same determination that produced this control will be helpful in mastering the use of the new palate. *This also applies to obturators.*[2] Several schemes of postoperative speech training have been devised, among which is the teaching of a foreign language that has not been previously attempted by the pupil. A simple and rather effective plan, devised by Bigelow, is given below, and is the one we employ.

"Begin with the only consonant which a patient can usually best articulate, namely *t* in *tar*, and gradually lead to the rest, constantly referring to the acquired *t* as a point of departure.

"The great difficulty in pronouncing correctly with a cleft-palate is in distinguishing the nasals from the mutes: Thus *p–b* from *m; pap* or *bab* from *mam; t–d* from *n; tat* from *nan; k–g* (hard) from *ng*. *Tar* is well pronounced by most beginners with an obturator.

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[1] Brophy: Oral Surgery, 1916, p. 734.

[2] Italicized by E. H. M.

"When the beginner can pronounce *stark* and *car* he has the key to most of what here follows. The above words should be practised carefully and should be spoken loudly, or as the elocutionists say, 'exploded.'

"1—*tar artar kar arkgar kar.*

"2—*kar arkar arkgar kgar gar.*

"3—*kar arkar arkdar kdar dar.*

"4—*kar arkar arkpar kpar par.*

"5—*kar arkar arkbar kbar bar.*

"6—*kar arkar arklar klar lar.*

"7—*kar arkar arksar ksar sar.*

"Practise all the above with the following vowels:

"8—*o* as in *coke.*

"Thus, instead of *kar, akar, ko–oko–oklo–klo–lo.*

"9—*a,* long as in *cake.*

"10—*i* as in *kite.*

"11—*e* as in *keep.*

"12—*u* as in *suit.*

"13—*kar arkar arngar arkar arngar kar ngar bar mar.*

"14—*tar artar arnar artar arnar tar nar dar mar.*

"15—*par arpar armar arpar armar par mar sar rar.*

"Practise reading loudly from a book.

"A patient, painstaking teacher and a docile earnest pupil are two factors that go a long way toward success.[1]"

The fact referred to above, that a patient who has learned to speak with a cleft velum must be educated to the proper use of the reconstructed one, holds good also in the use of an artificial palate. For the successful production of speech with such an appliance, training will be found more necessary and difficult with the patient, child or adult who has acquired imperfect speech, than with the child who has not made such attempts. In either case the defective palate is unable to form the sounds correctly, but repeated attempts to do so result in a more or less established coördination of motor nerve impulses and abnormal muscular activity. This habit hampers the patient in learning to control and use the muscles with an artificial palate in a manner which, if it cannot be called normal, is at least essential to the operation of the appliance. Moreover, to add to the difficulty, the patient's ear becomes accustomed to the sounds he makes, so that he is, to a certain extent, unable to distinguish between these faulty forms of speech and the correct ones.

The *kind of training* depends largely on the age of the patient and his environment, but must be of the most elementary character in the beginning, as pointed out by Bigelow in the lines just quoted, and quite similar to that for other speech defects. The simplest sounds must be undertaken one at a time, and it is evident that the patient must be taught first to recognize the correct sound before he can learn to produce it correctly.

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[1] Blair: Surgery and Diseases of the Mouth and Jaws, 3d ed., 1920, p. 245.

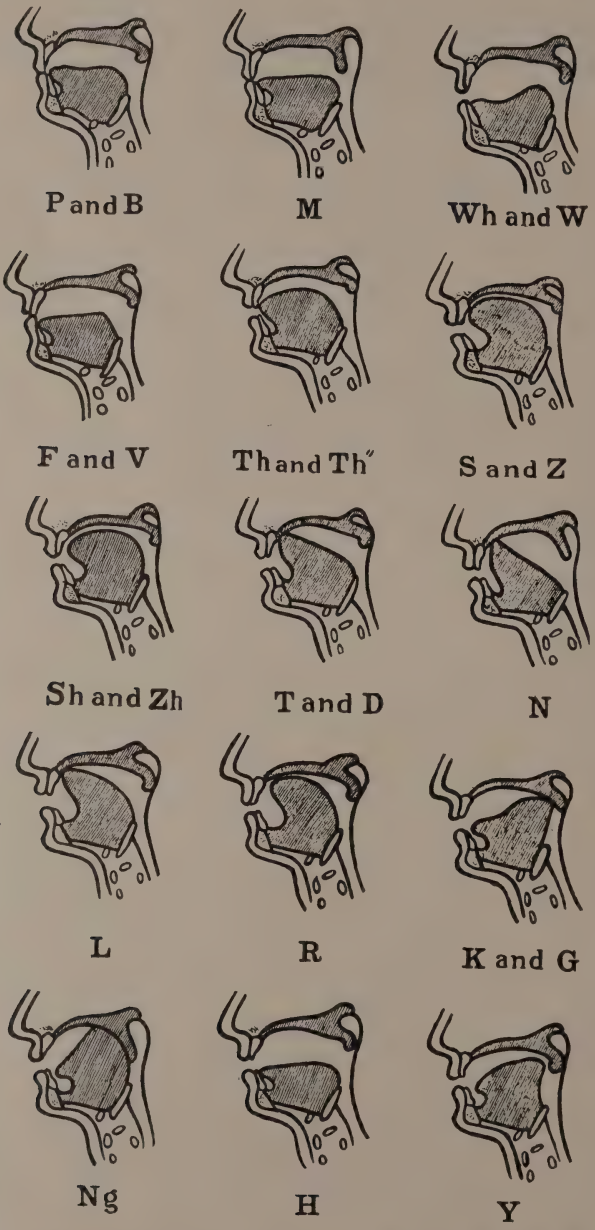

Fig. 847.—Diagrams illustrating the physiological alphabet, showing the relative positions of the soft palate and tongue in the formation of the consonant sounds indicated by the letters. (New York Medical Journal.)

The vowel sounds can usually be uttered by the patient with a cleft-palate, but not distinctly. When their resonance and pitch have been improved with the instrument in place, a feeling of confidence is gained which will encourage the patient in further efforts with the consonants. Many of these are so much alike, even when uttered perfectly, and the manner of their formation is so similar, that the patient will only be confused if the attempt is made to establish the finer distinctions at first. Words beginning with *k* or *g*, or *w* and *v*, or *b* and *f*, present this similarity in the formation of the initial letter.

Reference to the accompanying diagrams shows in a graphic manner the tongue and palate relations in the formation of consonant sounds (Fig. 847).

The subject of defective-speech training in itself constitutes an extensive and difficult problem which is receiving the increasing attention of the educational authorities in training teachers especially for that work. If the cleft-palate patient cannot have the services of such a teacher, nor of a teacher of vocal music, it is essential to enlist the aid and coöperation of parents to the end that whatever training is undertaken be simple and gradual, also that an environment of careful and precise speech be provided if possible.

TECHNICAL PROCEDURES.

The production of a prosthetic appliance for a cleft-palate consists of several steps or stages, including the following: (1) The examination or survey of the mouth; (2) securing the impressions for record casts and for working casts; (3) the making of the casts; (4) molding and carving the models or patterns for the artificial palate and for the denture; (5) making the molds; (6) the production and assemblage of the component parts. These procedures will be taken up in this sequence in the following pages.

Examination and Preliminary Treatment.—After the decision has been reached as to the type of appliance to be used for a cleft-palate, which may require only a superficial examination, it is imperative that a thorough examination be made preliminary to undertaking the actual construction work. This should be a detailed survey, including not only the consideration of all the physical conditions present, but a plan of the appliance itself.

Under physical considerations, the anatomy of the parts and the degree of abnormality must be noted. Even if all the teeth be present and in good condition, which is seldom the case in cleft-palate patients, it will be necessary to compare the width of the arch, its shape and curvature and its symmetry with the normal. The height and curvature of the vault or roof, as determined by those portions that are present, must be carefully noted, and an estimate made of what would be a normal vault for the case. It may be necessary to arbitrarily establish the height and curve of the vault in the appliance to be constructed.

The number and condition of the teeth present must be considered from several standpoints, among which of paramount importance, and demanding about equal consideration, are the possibilities of their use for the retention of the cleft-palate mechanism, and for the normal function of mastication. If the cleft be of slight extent and of such a nature that it may be corrected by a velum which can be ultimately retained by the sides of the cleft alone as advocated by Case, the teeth need receive little consideration as a means of retention for the appliance. If, on the other hand, the cleft be an extensive one, requiring both a denture and an obturator or velum, then the remaining teeth must be called upon for a large share in the successful retention of the apparatus, while at the same time their masticating function is conserved. In order to disclose their physical capabilities for such dual service, a knowledge of the number, direction, length and shape of their roots is essential. This, of course, can best be gained by the use of the roentgen ray.

Another point in the consideration of the teeth present, is their condition with regard to caries and possible pulp involvement, or the extreme condition of apical abscess, which again makes the use of the roentgen ray imperative.

It is evident that it would be folly to depend upon teeth for retention of the denture and palate mechanism which have any chronic involvement of the peridental membrane, either in the apical region or more generally as the result of so-called pyorrhea.

The roentgen ray examination should in no case be omitted, even if a full complement of teeth be present, or even if none are visible and the mouth is apparently edentulous. The existence of supernumerary and malposed teeth in conjunction with cleft-palate is so well known as to make it evident that they may be present in either of the conditions just mentioned in such positions as to seriously interfere with the prosthetic appliance by their partial eruption later.

In order that the design of the apparatus may be made quite definite at this time and to reduce the risk of inconvenient changes later, before taking the impression, it is essential to determine which teeth must be removed and which may be retained to advantage. To this end, all pathological conditions, including caries, and involvement of pulp or pericementum must be noted and receive the necessary treatment to effect a cure, or extraction resorted to if indicated. All restorative work upon the individual teeth, such as root-canal treatment, cavity fillings, crowns or inlays carrying frictional attachment devices, should also be completed before taking the impression for the denture or other retainer for the artificial palate. This is in conformity with the approved practice in all denture work.

In certain cases, at the discretion of the operator, it will be found convenient while the restorative work is being done upon the teeth, to take impressions of the cleft alone, for the purpose of study, or to proceed with the making of the velum or obturator, to be combined with the denture later.

In edentulous cases preliminary treatment is indicated in the surgical removal of pendulous or flabby tissue along the alveolar ridges, or of bony prominences, especially in the anterior region, where they may interfere with the proper setting of the artificial teeth; also the removal of any teeth under the mucosa in positions where they are at all likely to interfere with the denture later.

Impression Materials.—Those in ordinary use, namely, plaster of Paris and modeling compound, will meet practically all of the requirements in cleft-palate work. Wax, formerly used for building up or extending impression trays, and for certain parts of the impression, is now replaced to better advantage by modeling compound. Of the several varieties of the latter on the market, two are especially useful for these purposes. The S. S. White product, black in color, known as tray-forming compound, is, as the name implies, especially adapted to the purpose of molding an entire tray for the insertion of plaster in taking the impression proper, or for extending the edges of metal trays. The Kerr Perfection Compound, attaining the maximum of softness at a comparatively low heat, and hardening readily, is particularly adapted for use in the cleft impression and for obtaining the fine detail in the vault and around the teeth.

Plaster of the quick-setting variety, known as impression plaster by manufactures and dealers, is needed for certain parts of the impression. In some cases it will be found that compound will not yield the desired result in the cleft impression and plaster must be employed. If the impression be taken in sections, or with a core, as is most frequently necessary and desirable, or if a base-plate has been made first to carry an extension impression into the cleft, plaster is necessary for the final impression including the teeth, in order to secure fine detail without distortion. In other instances, for example, where a velum is to be constructed and it is necessary to include some of the upper or pharyngeal surface of the soft tissues bordering the cleft, a core of compound is advantageously used to carry a small amount of plaster to this area and to hold it there while setting, thus minimizing the quantity of plaster and controlling its flow.

Impression Plaster Compounds.—In addition to the finely ground, quick-setting plaster for impressions, compounds of plaster generally known as self-separating plaster have come into more or less general use. (See chapter on Impressions of the Mouth.) This can be advantageously utilized for cleft-palate work. Such a compound is particularly useful where deep undercuts exist, which make separation of the impression from the cast by other methods difficult and increase the danger of mutilation of the cast.

Study Models.—For purposes of preliminary study and as a permanent record, it is advisable to make casts of both the upper and lower jaws, for which the impressions should be taken before those from which the appliance is to be produced. While such study impressions need not be given so much time nor show so much of detail as the working impressions, their making will often reveal difficulties and suggest means to overcome them in the working impressions.

"*Gagging*" is one of the most serious difficulties met with in these cases. Almost invariably this occurs during the impression work, and in some instances when the appliance is first inserted. (See "Gagging and Means to Overcome," in chapter on Impressions of the Mouth.) The preliminary impression may be sufficient to overcome this as the patient becomes accustomed to manipulation and to the presence of a foreign body in contact with the soft palate. It will also reveal the extent of muscular activity and control, thus indicating the amount of assistance the patient may be expected to give in the final impression by voluntary manipulation of the muscles.

The casts obtained from the preliminary impressions may first be used for study of the case, and then preserved as permanent records. For this purpose they should be made of a hard, slow-setting plaster, appropriately trimmed and the necessary numbers, names and dates marked on them. By means of them many details of the later work can be determined, such as: The area of the palate to be included in the working impression; the size, shape and kind of tray to use; the occlusion of the teeth together with the antero-posterior relation of the two jaws; the area to be covered by the denture; the location and reciprocal balance of the retaining devices.

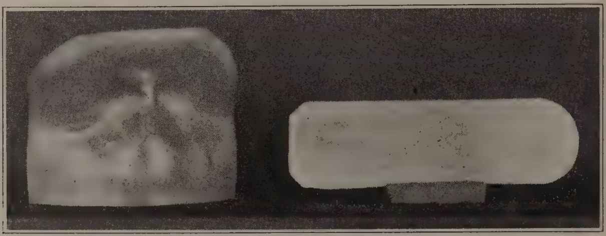

Fig. 848.

Infant Impressions.—For the purposes of study prior to operation and for record casts accompanying the case history, casts of infant cleft-palate cases are frequently required. It is desirable that such casts include not only the cleft-palate and the alveolar ridges, but the lip cleft and its relation to the nose as well; in other words, a combination of partial face mask and oral impression.

Since the surgeon's training does not include such difficult impression work, the aid of the dentist is often enlisted for this purpose. To secure the impressions for such casts, the author has used the following simplified technic successfully for infants of from forty-eight hours to six months of age:

No tray is used, merely a piece of heavy sheet tin (not tin plate) about $\frac{1}{8}$ inch thick, $1\frac{1}{4}$ inches wide and $4\frac{1}{2}$ inches long, shaped like a wooden tongue blade (Fig. 848). Modeling compound is built on this to take the impression in the mouth, including the palate cleft, the lip fissure and the border of the lip. Plaster is contraindicated for this part of the impression as being positively dangerous, since fragments of it might easily become detached and drawn into the lungs during crying. The assistance of the nurse is required in helping to hold the head, the child being laid on its back on a padded table.

The modeling compound impression is trimmed or additions made to it as necessary, with frequent reinsertions, until the desired area is included to the satisfaction of the operator.

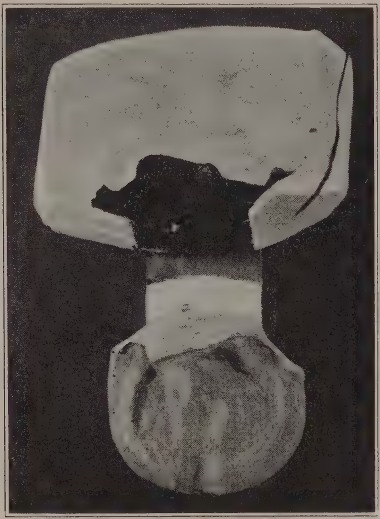

Fig. 849.—Mouth impression and partial face impression finished, ready to assemble. Blackened area of face impression registers with whitened area of mouth impression.

Usually the impression at this stage will extend into the lip fissure and well up into the nostril, or both nostrils if the harelip is bilateral. This is laid aside while a sheet of softened wax or modeling compound is molded to conform somewhat to the nose, the adjoining lip and cheek areas, and to include the eyes if desired (Figs. 849). Up to this point the child usually does not struggle, or, after a brief period of fretful crying in the beginning, remains quiet unless the operation be unduly prolonged.

After oiling the face, and plugging the nostrils with bits of oiled gauze secured on long ligatures, the modeling compound impression is put in place. While the nurse holds the impression, the operator mixes quick-setting plaster, using an accelerator also, fills the face mold and carries it to place, the base resting on the handle of the

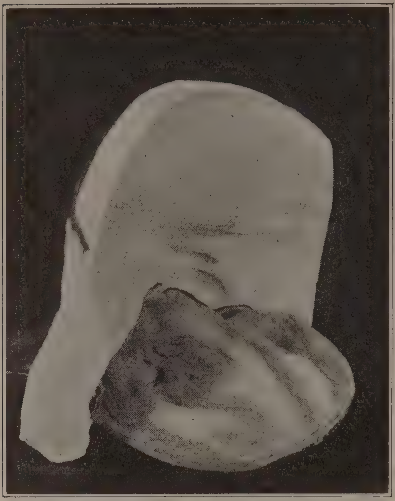

FIG. 850.—Mouth impression and face impression assembled.

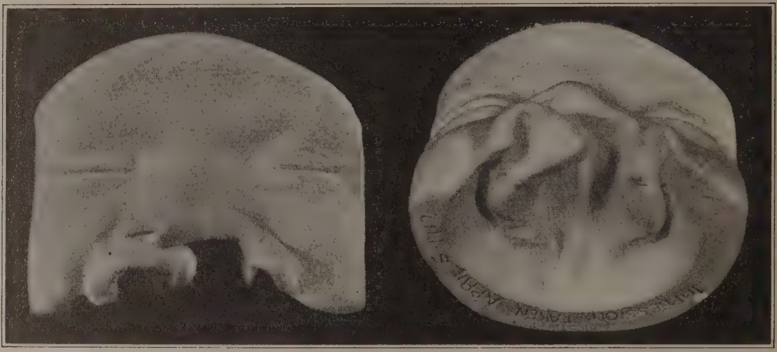

FIG. 851.—Infant cast, obtained from impression shown in Figs. 849 and 850.

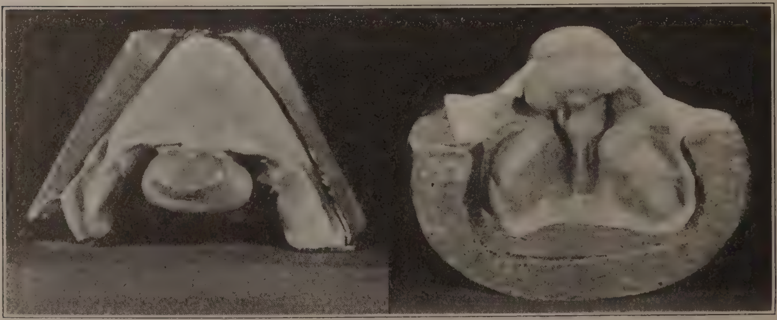

FIG. 852.—Infant cast, bilateral harelip and cleft-palate, obtained from composite impression.

improvised tray. The soft plaster flows over this handle and the edge of the lip, joining with the impression in the mouth. As soon as it sets sufficiently to fracture sharply, which should not require more than a minute and a half, the face impression is easily removed, and the mouth impression is withdrawn separately. During this stage the child must breathe through the mouth, and will usually struggle, and the assistance of the nurse is sometimes required to draw the tongue forward or hold it down with a tongue blade to permit air to enter.

The two parts of the impression (Figs. 849 and 850) are easily joined, as there is a definite relation established by the plaster in contact with the handle of the tray. When suitably secured in this relation and surrounded by a matrix of wax or oiled paper the interior of the composite impression is varnished and the cast poured in the usual manner (Figs. 851 and 852).

Materials for Casts, Models and Molds.—For study and record casts, ordinary plaster is well adapted. For the working casts one of the "hard" plasters or plaster compounds which have recently come into more general use, such as Weinstein's or Healy's "artificial stone," Calsilith, or Spence's plaster compound should be used. (See chapter on Casts and Models.) For models or patterns of the obturator or velum itself, base-plate wax permits of modeling and carving on the cast with comparative ease and will maintain its form fairly well for brief periods when tried in the mouth. Modeling compound, such as is used for the impressions, can be used also for this purpose to very good advantage. It is somewhat more difficult to mold on the cast and to carve, but will maintain its form indefinitely for trial in the mouth. Prepared modeling clay or wax, known as plastine or plasticine, is found useful in producing a tentative trial form or one for demonstration purposes, but has an odor and taste, which makes it somewhat impractical for trial in the mouth. It can be molded on the cast and additions made to it with greater ease than either the wax or the compound. It can readily be given a smooth surface and a pattern made from it can be "invested" in the flask for reproduction in vulcanite, or used as a pattern for producing a mold with any of the plaster compounds or magnesium oxychloride. It takes varnishes readily, and when it is to be invested a coat or two of sandarac, laid on with a brush and given time to dry thoroughly, will insure a smooth glossy surface on the plaster poured against it.

The *mold* in which the velum is to be vulcanized, if intended for repeated use, that is to say, a permanent mold, is usually made of metal.

For this purpose tin, Babbitt's metal or type metal are used. In making a trial velum, the form of which may need to be materially changed later, hard plaster will serve equally well if covered with tinfoil. (See chapter on Vulcanite.) The mold for an obturator, which will probably need renewal only at long intervals of several years, is usually made of plaster, which is, of course, destroyed during vulcanization. The use of Sorel cement (magnesium oxychloride) has been suggested for both of the above purposes. It can be poured into impressions in the same manner as plaster when confined by peripheral walls supplied by a sheet of wax or metal, its surface has a high gloss and, when thoroughly set, it can be vulcanized upon without any apparent effect on its density or hardness. Its use for the velum mold would very greatly simplify the procedure, as it would permit the making of the mold in two parts instead of three, as usually required when made of metal, and also obviate the necessity for making plaster models of the separate parts in order to reproduce them in metal.

Construction Details.—The simplest form of palate apparatus is that of a vulcanite plate incorporating a plug or obturator for an acquired perforation. Many of the details of its construction are identical with similar steps in the making of the more complicated devices for congenital cleft-palates. So far as they are applicable they may be considered fundamental.

Therefore the following description of these steps will serve for both types, and the variations necessary in constructing the velum and obturator proper will be noted later.

To make a plate-obturator for a small circumscribed perforation only a simple impression is needed, and any tray that will approximate the curvature of the vault will serve the purpose. For an extensive palate perforation, it is best to adapt and trim such a tray to fit the mouth, especially if the mouth be edentulous. (See chapter on Impressions.) In such cases it is often of great advantage to take an impression, paying but little attention to that part entering the perforation except to trim it away.

From this a cast and vulcanite base-plate are made, the base-plate being used as a tray on which to build and adapt the compound for perfecting the impression of the perforation. This part is reproduced in vulcanite when the teeth are mounted in the second vulcanization. For such impressions modeling compound is best suited, as it can be added to or modified in repeated trials. Withdrawing it from the perforation before it is fully hardened when inserted the first time avoids the possibility of a mass, too large to pass through the opening, becoming set in the nasal cavity, as might readily occur with plaster. Any surplus which extends into the nasal cavity should be cut away, leaving only a flattened plug or drum level with or even below the nasal floor. In case it is desired to derive some retention from the plug, it must be thicker, with its edges slightly hollowed to form a groove fitting the border of the opening. The elasticity of the tissues permits the insertion of the tight-fitting plug, but it must not exert any pressure when in place, otherwise rapid resorption of the border of the opening may occur (Fig. 853).

If some of the teeth are present and are to be used for retention, the impression need include only their lingual aspects and the rounded border of the perforation. After trimming the trial impression to these limits, additions of compound are made by "tracing on" at points where needed, and the impression perfected by reinsertion as many times as necessary.

In this case any devices such as clasps or other frictional attachments for retention are to be made separately. After the base-plate is made, and is in place in the mouth, the attachments are mounted on the teeth and their relation to the base-plate established by a second impression of plaster, including all the teeth and contiguous portions of the base-plate. When removed from the mouth and reassembled, the plaster parts and the base-plate constitute a composite impression from which the cast is made. The details of taking the bite and mounting the teeth are then carried out in the usual manner. The base-plate may be either included in the second vulcanization and new rubber added, or, preferably, discarded and replaced by new rubber entirely. In order to follow the latter plan, all "undercuts" must be omitted from the palate surface of the first impression and base-plate, until the base-plate is fitted in the mouth, at which time all details of the border of the perforation are obtained by the addition of compound as previously described, which then becomes a part of the composite impression and may be removed from the second cast without difficulty when softened by heat.

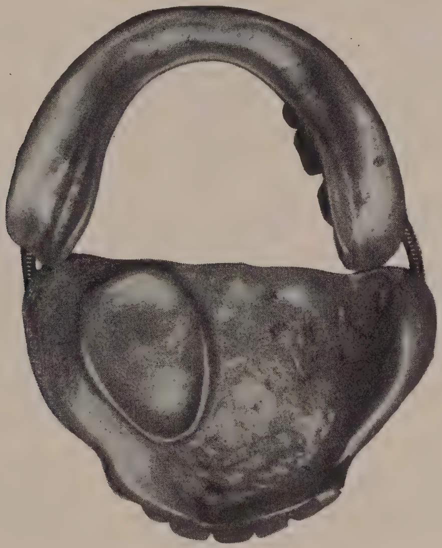

Fig. 853.—Cast aluminum upper denture with plug obturator for acquired perforation (surgical). Retained in conjunction with lower by coiled springs. (Wilson.)

The procedure described above for obtaining the impression and afterward establishing the relation of the remaining teeth and retention devices to the base-plate portion of the denture in two stages conforms to accepted practice in constructing partial dentures. It simplifies the impression-taking to a great extent, and promotes accuracy. It is thoroughly endorsed by the author as being applicable not only to the construction of the comparatively simple denture-obturators for acquired palate lesions, but also to similar parts of the mechanism required to serve the dual purpose of retaining a velum or obturator and restoring impaired masticating function in congenital cleft-palate cases.

The variations necessary for metal base-plate construction will be obvious, since the method described involves the use of the vulcanite base-plate in precisely the same manner as a metal base.

No consideration is given here to extensive palate lesions including the loss of large portions of the maxillary bones, as this more properly belongs under the head of Facial Prosthesis.

Many ingenious devices for this purpose have been developed as a result of experience in the World War, including frames and bars for replacing portions of both the maxillæ and the mandible, as well as masks of metal and plastic restorations of portions of the face and missing features.

The study of these is an extensive and extremely interesting subject in itself.

For the production of an *artificial palate* for a *congenital cleft*, with the necessary retaining mechanism, two general plans are followed. One of these, and probably the original method for an obturator which is an integral part of a vulcanite denture, consists in securing a cast of the parts involved including the cleft. On this cast, patterns in wax of the obturator portion are formed and made continuous with the plate used for retaining purposes in the respective areas to be occupied by each. These are reproduced in hard rubber by vulcanizing on the original cast, thus destroying it (Fig. 854).

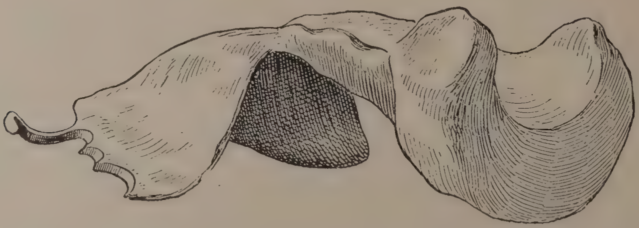

Fig. 854.—Obturator for a cleft-palate, Suersen type. (Warnekros.)

More recently it has been recognized that this procedure was not entirely satisfactory, since the obturator must fit tissues that move, while the denture rests upon a fixed base. To secure in one impression an accurate reproduction of the vault and the entire dental arch involves great difficulty. Moreover, the cast from such an impression represents the borders of the cleft in a contracted position. Due to the sensitiveness of these tissues, contact with the impression material causes the muscles to draw the soft palate upward and backward, partly closing the cleft, while the impression tends to increase this effect by pressing the tissues back. It has been shown that it is desirable to have a cast representing the borders of the cleft in their *relaxed* position and the posterior wall of the pharynx in its *contracted* state.

Such a cast can be produced in two stages as follows: The first cast secured, and which represents the palate in its contracted state, is used as a guide on which to mold a mass of plastic impression material in the area representing the parts that move, together with a temporary base-plate, the two being held together by a wire frame in the form of an extension from the posterior border of the base-plate, made separable, with sockets in which the frame may be fitted. This mass can then be carried to the mouth for modification, where by trimming or adding to it, as indicated by repeated trials and observation of the muscles in action, it can finally be made to represent the parts in the desired condition. This partial second impression has thus in reality become virtually a model or pattern of the part to be supplied for the cleft. When returned to the cast on which it was molded and new plaster poured around it, a composite cast is produced upon which the relative positions of the teeth, the base-plate and the artificial palate may be observed and reproduced at will. The wax patterns for these parts are then perfected and removed for reproduction separately, during which process the necessary artificial teeth and retention devices such as clasps are incorporated. The denture and palate are then assembled and fastened together by some form of bolt or screw, sometimes requiring another impression to accurately establish their relations in the mouth.

These complications in securing the composite cast and final assembly have naturally and logically led to the more rational plan of completing the denture or other supporting part first, and then making the artificial palate as an extension or addition to it. This plan presents so many advantages and simplifies the impression technic to such an extent that it is given in detail.

This description applies to the making of a hollow vulcanite bulb and a vulcanite denture for a case in which the cleft extends through the soft palate and into the hard palate, but the technic is easily modified as indicated for use with a metal plate, or for a cleft in the soft palate only, or to make a soft rubber velum.

It is assumed that a study model including the cleft in the soft palate has been made. With this at hand, a careful examination of the mouth is made to determine the dividing line in the posterior part of the vault between the tissues that move by muscular action and those which are stationary. Watching the muscle movements while the patient attempts to utter the vowel sounds with the mouth widely opened, will afford an approximate idea of the amount of muscular movement and the limits to which it extends.

A somewhat different action will be elicited by touching the soft palate with a blunt instrument, or by directing a fine stream of cold water against it from a water syringe, thus causing the patient to begin the act of swallowing. From these observations and by sketching on the model the relative positions of the soft movable parts and the hard tissues, the line is determined along which the posterior border of the proposed plate is to terminate.

A tray is adapted to include this area, the impressions taken and the denture produced as previously described, with the necessary retaining devices and artificial teeth. If the denture is to be made of metal, the plaster model from which the die is made must have the cleft filled in with wax, so that the denture will bridge the cleft and not enter it.

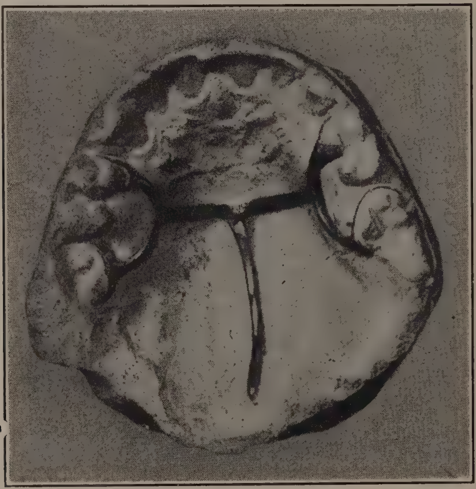

FIG. 855.—Frame with clasps, used to support an obturator. (Wilson.)

When no artificial teeth are needed, or if they can be supplied to better advantage by a bridge, then the structure for supporting the artificial palate should be of the smallest size possible to afford the necessary strength; or it may be a mere frame carrying the retention devices, so that no appreciable area of the roof of the mouth is covered.

Such a frame as shown for reënforcing a vulcanite denture can be made to serve this purpose by modification of the piece extending posteriorly so that the palate may be fastened to it, by making this piece wider and flat to receive a screw hole (Fig. 855).

During the making of the denture, means are provided near its posterior border for the attachment of the extension which supports or incorporates the artificial palate as follows:

Some small round-head screws with square nuts are obtained from a dealer handling supplies for small machine-work and model-makers.

Flat-head screws may be used, but provision must be made for countersinking them when finishing the work, which involves unnecessary complication. The sizes known as No. 1, with 72 threads per inch, and No. 2, with 56 threads per inch, are suitable. They may be had in brass which can be heavily gold-plated to prevent oxidation. No. 1 is approximately 14-gauge diameter and No. 2 is 12-gauge.

Similar screws of the flat-head variety may easily be made to order by the prosthetist, of clasp gold or other alloy if preferred, with the aid of a small screw-plate and a little swaging tool.

The screw-plate or die and the corresponding size tap may be obtained from the dealer and the swaging tool made from a piece of square rod steel $\frac{1}{4}$ or $\frac{5}{16}$ inch in diameter. The rod is drilled near one end with a hole the size of the screw to be made. With a large round bur of the size desired for the finished screw head, this hole is countersunk on one side to half the diameter of the bur.

The same bur being used later to countersink the screw in the work simplifies matters and insures a good fit.

To make a screw, a length of wire is threaded in the die, and a piece cut off somewhat longer than the length desired for the finished screw.

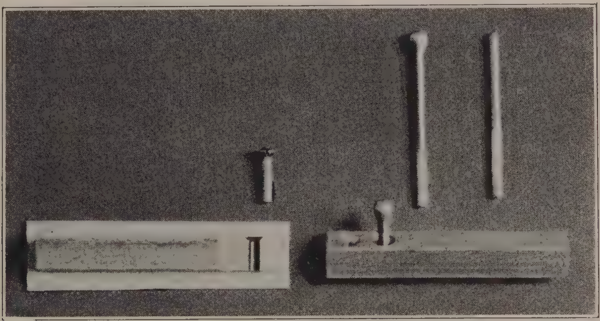

FIG. 856.—Swaging tool and a cross-section of same, with screws in different stages of construction.

One end of this is "balled up" by melting in the Bunsen flame, or solder flowed upon it to form a head. To give the head the proper shape it is only necessary to hammer it down in the swaging tool so that it conforms to the countersunk part and file it off flat, even with the surface of the tool. The slot is then cut with a jeweler's saw (Fig. 856). The nut can be made of any shape wanted by cutting a piece from gold plate of the required thickness, drilling a hole and tapping the thread.

While waxing up the base-plate pattern, a square or rectangular nut, is embedded in the wax near the posterior border, in that portion which is thickest where it extends into the cleft in the hard palate.

The nut should be grooved on its edges with a file or stone for retention in the rubber, or bits of plate soldered on it for this purpose. The thickened portion of the base-plate where it enters the cleft should be trimmed down from the nasal side until it is only of sufficient bulk to afford secure retention for the nut when vulcanized, and shaped into a triangular ridge extending antero-posteriorly. The anterior part of the obturator will cover this ridge.

The screw is inserted in the nut and through the wax, with its head extending on the lingual surface $\frac{1}{4}$ inch or more. When flasked and the wax removed, the nut will be held by the screw so that rubber can be packed around it. If the protruding part is wrapped with a bit of tin-foil the screw can be readily removed after vulcanization.

With a metal denture it is only necessary to solder the nut to the nasal surface, its rectangular form providing a definite means of registering the position of the obturator and preventing its rotation on the denture.

A tongue or extension of brass, 18 gauge in thickness, $\frac{1}{4}$ inch wide and long enough to overlap on the posterior border of the denture about $\frac{3}{8}$ to $\frac{1}{2}$ inch and to extend well back into the cleft, is fitted and a hole drilled to admit the screw near its anterior end. This extension is to carry the impression material for the cleft, and should be bent to conform to the antero-posterior curve of the tissues of the soft palate. If for a narrow cleft, it may be merely a rectangular piece of metal (Fig. 857), but for a wide cleft it can easily be made wider and forked to give better support to the larger amount of impression material required (Fig. 858).

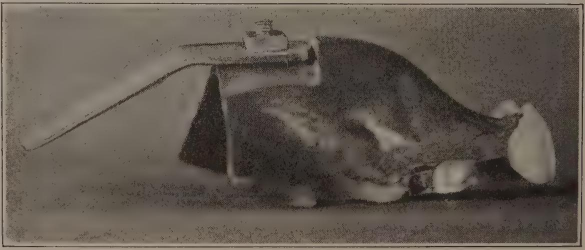

Fig. 857.—Vulcanite denture with extension bolted on.

The extension is bolted on the nasal surface of the denture with a loose nut above and the screw head below on the lingual surface, so that it may be reached with a screw-driver when in the mouth (Figs. 857 and 859). Impression compound is built over and around the extension and as far forward as necessary on the nasal surface of the denture. By repeatedly softening and inserting in the mouth, trimming or adding compound as indicated, and with the assistance of the patient in exerting muscular force if possible upon the material when at its softest stage, an approximate model of the obturator or velum is obtained (Fig. 860). This may be left bolted to the denture and worn by the patient temporarily with the warning to avoid hot liquids.

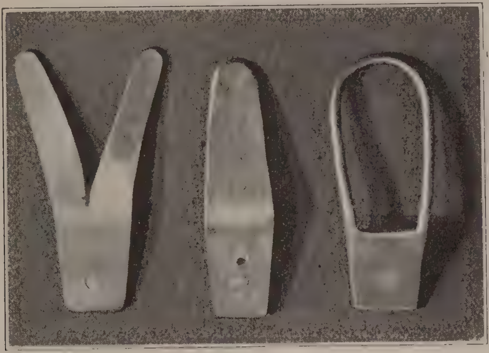

Fig. 858.—Three forms of extensions.

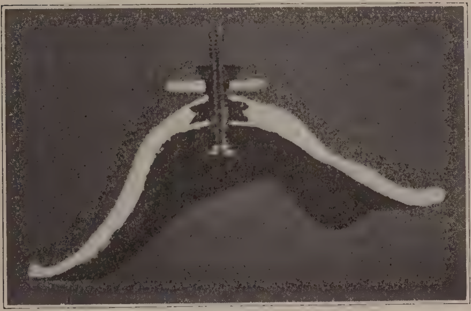

Fig. 859.—Cross-section of vulcanite base-plate, with embedded nut. Screw and extension in place, secured by nut on nasal surface.

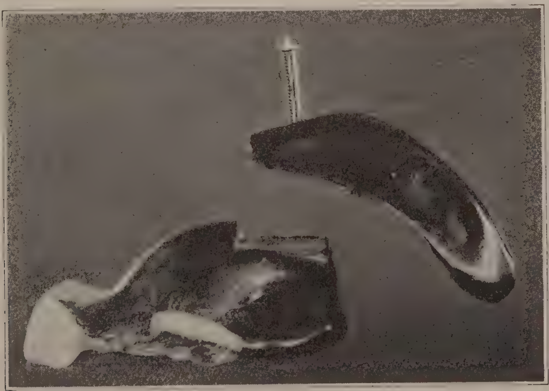

Fig. 860.—Denture with model of obturator in compound, separated, ready to flask model for vulcanizing. When finished the obturator will be secured by the screw in the relative position shown.

Such a trial may suggest changes in size or shape or verify the correctness of the trial model.

The modeling compound, even in as soft a state as it can be handled, offers some resistance so that the weak palate muscles cannot close through it to their fullest extent. Consequently it must usually be carved to smaller dimensions, using the groove formed by the sides of the cleft as a guide. At the posterior end especially, where contact is to be made with the posterior wall of the pharynx, only repeated trial and modification by trimming or adding can determine the correct shape and size.

If desired, the method described by Case of utilizing a wire frame on which to mold the velum model can be adopted by soldering such a wire loop to a shorter extension (Fig. 858) than the one described above, and bolting it on a stiff piece of metal for a handle, or using a long screw as a handle.

When the model is completed, or at any intermediate stage, it can be transferred to the denture to test its relative position.

It may be found necessary, in order to obtain the proper detail of the borders of the cleft without pressing them out of their normal position, to use plaster for the final impression.

In this case the core of compound is trimmed to make room for the plaster and roughened for its attachment; a thin layer is spread on and carried to place. When set, it will be found a simple matter to remove the screw from the under side, slip the impression backward and remove it separately to avoid as much as possible the fracturing of any delicate fragments around the edges.

The form of the nasal and lingual surfaces is of considerable importance. The lingual surface should be carved flat or slightly hollowed, and made continuous with the posterior border of the denture. If the divided parts of the uvula are pendent and freely mobile, provision should be made for them to close under the obturator on its posterior lingual surface by reducing its bulk in that area to the necessary extent. In large obturators it has been found advisable for its beneficial effect on the resonance of the voice to make the nasal surface freely hollowed out from side to side, while the antero-posterior curve as seen in outline is governed by the height of the arch made by the muscles in their contracted state, the side walls of the obturator being made only high enough that the muscles cannot rise above them.

When carved and trimmed to the form and size found to be best suited to the case, the obturator pattern is detached from the denture, the hole left by the screw plugged with wax, the surfaces varnished and finally flasked in the usual manner for vulcanizing, causing the flask to separate along the line of the upper border of the pattern. The brass extension and nut will come out with the wax, leaving the interior of the mold clear for the packing of the rubber. For the sake of lightness and to avoid as much as possible the nasal quality of voice often accompanying the use of an obturator, it is advisable to make it so that the greater part of the body will be hollow. This may be done in the following manner: Three pieces of rubber are cut from patterns, one piece made to cover all of the side walls of the mold, and one piece each for the top and bottom. Where they are to join, the edges are brushed with chloroform and pinched together with pliers. When placed in the mold, the joints are reënforced with thin strips of rubber packed internally along the line of the joint, which has been moistened with chloroform. The greatest care must be used in putting on the top piece, which must be pinched at its edges to form the joint with the side piece before the flask is closed. Water is enclosed in the bulb to fill it about three-fourths full, but must not be allowed to touch the edges, as a defective joint would thus be likely to result when the cover piece is put on. The steam generated during vulcanization, if no leaks are present, will hold the bulb distended against the sides of the mold until its form is fixed by the vulcanizing process. Slow vulcanization and a low temperature are best adapted to this purpose. At least forty minutes should be taken to bring the temperature from the boiling point to that at which it is to be maintained for the required time. As indicated by thermometer, 290° F., which is approximately 300° in the interior of the vulcanizer, will produce good vulcanite if maintained for two and a half hours, and the vulcanizer should be allowed to cool slowly afterward.

When the bulb is removed and polished its relation to the denture will be readily indicated by the triangular ridge before referred to and the corresponding depression in the obturator.

The two are fitted together and a hole drilled through the bulb, using the screw-hole in the denture as a guide. The water remaining in the bulb can thus be drained.

An alternative method is to fill the interior of the bulb with plaster when the rubber forming the bottom and walls has been placed, then to put on the top piece quickly and to close the flask. It is opened after the plaster has set and the excess plaster is trimmed and washed away where the edges join. A little fresh rubber is added along this line, the flask finally closed and vulcanization carried out in the usual manner. If removed from the flask immediately after cooling, the plaster in the bulb will be found in a softened condition and may be removed through the hole bored for the screw by stirring it up with a bent wire and washing it out with a stream of water from a water syringe.

When an obturator is of smaller size so that it is necessary to make the anterior part solid where it overlaps the denture it will be found best to drill a hole for the removal of plaster or water as the case may be, at some other place, preferably on the nasal surface. The hole may finally be filled by means of a piece of screw which is later cut off flush with the surface.

To assemble denture and obturator, insert a screw with the head on the nasal surface of the obturator, smear a thick solution of chloropercha around the screw head and between the obturator and denture to make a water-tight joint, and set the screw home. After cutting off and polishing the projecting screw end on the lingual surface, the appliance is ready for use.

Variations in the method of using the screw and nut with the extension will readily suggest themselves as the necessity arises. For a cleft in the soft palate only, when it is not desired to extend the denture so far back, instead of a nut being used, the extension itself, made of clasp gold, and with a thread tapped in the screw hole, has its anterior end embedded in the posterior border of the wax pattern of the denture. By wrapping this part with heavy gold-foil and inserting the screw so that when waxed up its head will protrude lingually, the extension will be fixed in its relative position to the denture when vulcanized, and can also be removed and replaced at will. When flasking this assembly of wax pattern, metal extension and screw head protruding, it is necessary to make sure that these metal parts will be held firmly in the plaster when the flask is opened until the rubber is packed around the portions which are to remain embedded in the denture. With the obturator vulcanized on the posterior end, the extension is finally bolted on the denture with a flat-head screw countersunk from either the lingual or palatal side. With a metal denture the extension carrying the obturator can be bolted directly on the lingual surface, with one or two screws countersunk from the palatal side, and its edges rounded to avoid irritation to the tongue.

For a velum a stud or post is required standing up from the palatal surface of the denture over which to "button on" the velum when made. A screw made of gold wire, threaded only at the end, when inserted to the limits of its thread in the nut embedded in the denture provides such a stud, removable if necessary for repairs or modification.

Making the Velum Mold.—A vulcanite flask, with the inside ground and polished to remove all roughness, is suitable and convenient. The velum model of wax or compound is to be embedded in plaster in the flask in such a manner that three sections will be formed, one at a time, which are to be reproduced separately in metal and again assembled in the flask as a complete mold in which to vulcanize the soft rubber.

A piece of brass or nickel-silver wire is heated and pushed through the screw-hole in the velum model so that it protrudes slightly on the nasal surface and $\frac{1}{4}$ inch or more on the lingual surface. This wire will finally be incorporated in the metal mold and produce the hole in the velum necessary for fastening it on the denture. The model is then partly embedded, lingual side down, in plaster in the flask (whose interior surface has been covered with vaseline or oil) in such a manner that the line of separation between the sections will come along the thin edge. When the plaster sets, it is removed from the flask, with the model still in place, and trimmed along this line. It is then returned to the flask, its upper surface varnished, and the process repeated for the second and third sections (Fig. 861).

The model is then softened by heat and removed, each section is varnished on all surfaces, and separately invested in a suitable molding box or flask with a heat-resistant investment (plaster-silica mixture). When set, the flask is opened, the plaster section removed, a gate for pouring the metal provided, the investment thoroughly dried out by heat and the Babbitt or type metal cast into the mold. The wire pin which is left in the first plaster section when the velum pattern is removed must be transferred and left in the investment mold, so that it will be picked up by the metal when cast and appear in its proper place to provide the button hole through the velum by which it is to be attached to the post on the plate (Fig. 861). When the sections of the velum mold are completed, as shown in Fig. 862, they are to be assembled in the same flask in which the plaster patterns were made. The flask having been previously smoothed on the inside, the sections should go to place and fit snugly without any difficulty. All interior surfaces of the metal mold must be polished and just before use should be soaped to prevent adhesion of the rubber.

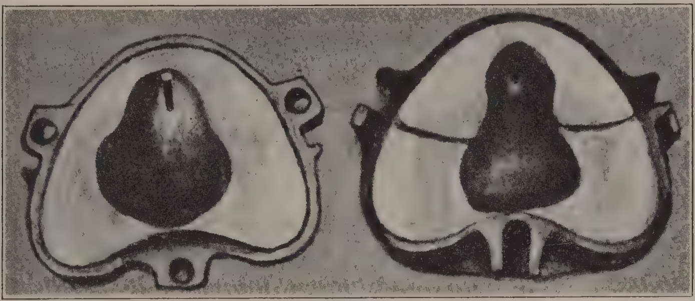

Fig. 861.—One section of plaster is cast in the lower half of flask, two in the upper section. Note pin in position. (After Wilson.)

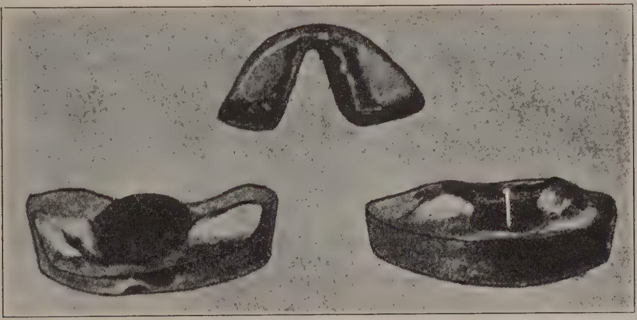

Fig. 862.—Three sections of a Babbitt's metal mold, with pin in position, before assembling in flask. (After Wilson.)

Velum rubber is identical in appearance with denture rubber but contains less sulphur (approximately 20 per cent of the amount of caoutchouc) and is vulcanized in the same manner. Each manufacturer furnishes specific directions for his product, but in general, preference should be given to the low heats and longer time. It cannot be polished after vulcanizing, but the imperfect or "feathered" edges of the velum may be trimmed with sharp scissors or seared with a hot spatula if necessary.

Development of Cleft-plate Mechanism by Different Men.—The problem involved in cleft-palate prosthesis is a peculiarly difficult and intricate one. It has challenged the skill, patience, ingenuity and knowledge of anatomy and physiological function of all who have undertaken it.

As might be expected, this has given rise to many divergent ideas held by the earnest and devoted men who have worked along this line, together with variations in design and technic, many of them of great merit and eminently practical.

While all of these cannot be included in this text, an effort has been made in the following pages to present for the benefit of the student some of those which have found a place in dental literature.

It must be remembered that the simpler the device for cleft-palate prosthesis, and the fewer its parts, the less serious will be the complications in regard to its cleanliness and need for repairs or readjustment, so that a simple appliance, though perhaps not attaining the maximum efficiency possible to a more complicated and delicate apparatus, may still be of greater advantage to the patient than one which requires frequent visits to the dentist for replacement or adjustment of parts, or whose sanitation is difficult.

VARIOUS TYPES OF OBTURATORS AND VELA.

The first obturator of record for a congenital cleft-palate is one described by Dr. Wilhelm Suersen, in 1867, at Hamburg, before a meeting of German dentists. The following excerpt from his article[1] is sufficient to make clear the essential features of its construction and function, and is introduced here largely for its historic value, as the instrument is frequently referred to by writers on this subject:

"These palates, which in all their parts are made of hard caoutchouc, consist of a teeth-plate suitably attached to existing teeth, and which at the same time covers the fissure in the hard palate (if such a fissure exists). Where the fissure commences in the velum, that plate terminates in an apophysis broad enough for filling up the defect. This apophysis is at the same time of such thickness as to keep up a contact between the high edges forming the sides of the apophysis and the two halves of the velum, even when the levator is in activity. To bring about this contact the more surely, the high edges forming the sides do not rise straight, but obliquely toward the outside. The lower surface of the apophysis, turned toward the mouth, lies on about an equal level with the velum, *if the latter is raised by the levator palati.* But when the velum hangs loosely downward, the back part of the artificial palate is lying over it. This back part, accordingly fills up the cavum pharyngo-palatinum, and in such a manner as not to impede the entrance of the air into the cavity of the nose when the constrictor pharyngeus superior is inactive. Thus the patient can without any impediment breathe through the nose. But as soon as the constrictor contracts the cavum pharyngo-palati—the muscle already named, reclines against the vertical back surfaces of the obturator. By this operation the air current is prevented from entering the cavity of the nose, and is compelled to take its way through the mouth, and thus the utterance loses its nasal sound."

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[1] Am. Jour. Dent. Sci., December, 1867.

The instrument illustrated in Fig. 842 is also of this type.

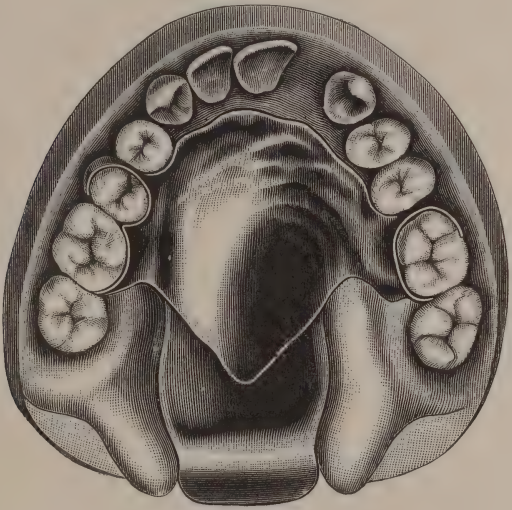

FIG. 863.

Later Modifications of the Suersen Obturator.—The principles enunciated by Suersen are fundamental, and practically all obturators function in this manner, but modifications have been made in the instrument for convenience and to increase the range of its application. Making the bulb hollow, as has been previously mentioned, lightens it considerably and having it separate from the denture makes it readily applicable to either a vulcanite or metal denture.

Ottolengui states these principles and describes some modifications of the Suersen device with pertinent comments as follows:[1]

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[1] American Text-book of Prosthetic Dentistry, 4th ed., 1913, p. 796.

"In Fig. 863 is shown a model with an obturator in position. The denture is made of iridio-platinum and the obturator is a hollow bulb of hard rubber. This figure shows the length of the obturator in relation to the uvulæ, as well as the manner in which the oral surface of the instrument fills the gap and completes the arch of the vault. In Fig. 864 the same instrument is shown in profile. It is seen that the rubber bulb is attached to the metal plate by passing over a bar which is soldered to the plate, a nut holding it fast. Thus the bulb may be removed in order to repair or alter clasps or to do anything requiring the operation of soldering which should be difficult to properly perform were the rubber bulb permanently attached. The figure also shows the thickness of the obturator which is so shaped that as the divided palate rises contact is preserved. This instrument is a modification of the original Suersen device.

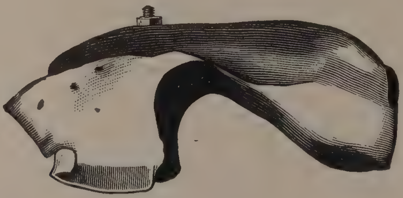

Fig. 864.

"In use, an obturator of this kind, unlike the artificial velum, is stationary in its position, but it is of such form that the pharyngeal muscles of the throat in the movements incidental to the production of articulate sounds hug the obturator, and so separate the cavity of the nose from the cavity of the mouth."

The Mitchell Vomer Restoration and Hinged Obturator.—Dr. Vethake E. Mitchell, of New York City, demonstrated an appliance with a hinged obturator and a nasal extension replacing the vomer bone, at a meeting of the Oral Surgery Section of the First District Dental Society of New York, March 25, 1913. The following excerpts and accompanying illustrations are from his paper.[1]

"Appliances of many shapes and of different materials have been made for the closure of the cleft, but with apparently little regard for the restoration of the nasal passages, to permit normal respiration, or the restoration of the resonance chambers for the improvement of voice and speech.

"In the appliance which I present to you, all these things have been taken into consideration, and an attempt has been made to restore all missing tissues and their functions.

"A division extends through the uvula, the soft and hard palate to the alveolar process. Vomer bone entirely missing.

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[1] Dental Digest, October, 1913.

"Nothing had been attempted surgically. At nineteen an obturator was made and considerable improvement in speech resulted. This was worn for seven years, when a second obturator was constructed on the same style. This was worn for almost five years. The case was then referred to me to see what further improvement could be accomplished.

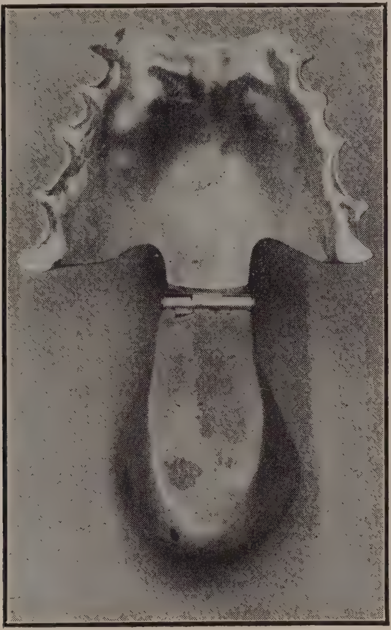

Fig. 865.—Mitchell hinged obturator.

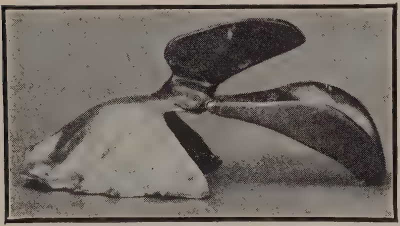

Fig. 866.—Side view of Fig. 865.

"With base-plate wax an artificial vomer was formed in the model. Its upper margin was closely adapted to the remnants of the septum. Its lower margin was adapted to the upper or nasal surface of the metal denture. This lower margin was spread out and thickened to replace the lost tissues of the hard palate. After imbedding in the wax at the posterior border that portion of the hinge intended for this part of the appliance, it was flasked and reproduced in hard rubber.

"The next step is to close the cleft in the hard palate with something that will stay in position and keep the cleft closed during the muscular movements of the palatal tissue. A piece of base-plate wax was doubled and shaped to fit the cleft snugly from side to side. This forms the roof of the mouth and the floor of the nasal passage. It widens out as it extends backward, forming a flange on either side. This flange laps over the upper edges of the palatal tissue.

"The other part of the hinge is imbedded in the anterior portion of the piece which is to close the cleft in the soft palate. The piece for the soft palate is then attached to the denture by putting the pin through both parts of the hinge. The soft palate piece must extend back sufficiently, and be so shaped that when raised by the muscles in the act of swallowing, it will touch the posterior wall of the pharynx so as to close the passage into the nasal cavity. This part is then reproduced in hard rubber, faced with pink, to more resemble the palatal tissues.

"Being solid, it has sufficient weight to keep it in position when the palate muscles are relaxed, and still is not too heavy for them to raise when contracting. This movement is possible because of the hinge joint. The whole appliance, being constructed of metal and hard rubber, is perfectly hygienic and non-irritating to the tissues."

The apparatus was exhibited at this time, and the patient, being present, demonstrated the difference in speech with and without the the appliance, followed by singing and other breath-control exercises. Judging by the discussion printed in full with the article, the demonstration was most convincing as to the success of the appliance. It is obvious that this appliance is applicable only to cases in which the cleft extends through both the soft and hard palate and with considerable loss of the structure of the vomer.

The McGehee "Universal Movement" Obturator.—Dr. W. H. O. McGehee, of New York City, at the meeting of the New Jersey State Dental Society, 1915, presented an obturator of novel and most ingenious design, which might well be termed a universal movement obturator, since it was so arranged in connection with the supporting denture as to have free movement in two planes or intermediate combinations of the same. It was made in the form of a thin shell, open on the nasal surface, but otherwise similar in shape to the usual hollow-bulb obturator and filling the cleft in the same manner.

Its essential features and the requirements which it is claimed to meet are quoted from Dr. McGehee's paper.[1] The descriptive matter is summarized and condensed by the present writer to conserve space:

"*Requirements of a Successful Obturator.*—It is now readily seen that a successful obturator should be capable, not only of upward and downward movements, but, in order that it may remain in perfect adaptation to the boundaries of the cleft under all circumstances, should really possess six distinct movements, that is to say: Vertical (upward and downward), antero-posterior (forward and backward) and lateral (right and left). The appliance which I shall presently describe is designed with this idea in view, and is presented to the profession after adequate and successful trial in many clinical cases.

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[1] Dental Cosmos, 1915, p. 1325.

"The appliance suggested consists of a metal or vulcanite denture with clasps, vulcanized or soldered into the heel of which is a clasp metal extension, on which rests the hard-rubber obturator (Fig. 867). From the center of the metal extension a screw-cut gold post with a nut on its end projects upward through the obturator. Vulcanized into the hollow portion of the obturator is a flexible clasp metal tongue, through which the upright screw-post previously mentioned passes, and in contact with which it is held by means of the nut on its end. On the under side of this metal tongue is a small gold hook, to which is attached one end of a spiral spring, the other end hooking around the upright screw-post. Another spiral spring extends from a similar hook, vulcanized into the posterior part of the upper hollow portion of the obturator, to the same upright post." . . .

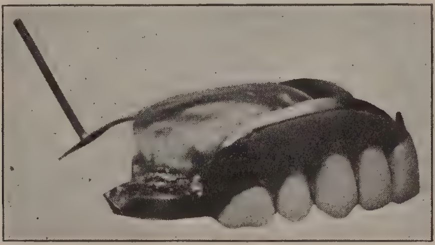

FIG. 867.—Metal denture (vulcanite attachment) with backward clasp-metal extension and screw-post. (McGehee.)

For the production of the obturator the steps briefly enumerated below are more fully described by Dr. McGehee's paper.

As a preliminary, a rough impression is taken and, from it, a cast is made, on which a tray made of modeling compound and provided with a wooden handle is built up. On this tray a second impression is taken by adding more compound and perfecting it by reinsertion in the mouth. From this impression a sectional model is produced, on which is molded in compound a model of the obturator provided with a wire handle. After trying in the mouth and modifying as necessary, the model is embedded in a plaster mold of three sections, and a core of plaster incorporated which permits of the model being reproduced in vulcanite as a shell having bottom and sides but no top. The paper thus describes the assembling of the denture and obturator:

"The obturator is placed in position in the cleft in the mouth, holding it in place by means of a string attached to it, which is passed through the nares.

"The metal or vulcanite plate is placed in position, and on the under surface of the obturator, by means of the perpendicular screw-post on the metal backward extension of the plate, the location is marked of an opening to be cut, through which the screw-post is to pass.

"The plate and obturator are removed, an antero-posterior opening, about ½ inch long, is cut through the under surface of the obturator at the point marked, and a like opening immediately above it in the metal extension in the hollow part of the obturator, these openings to be slightly forward of its center to allow for the backward play of the obturator.

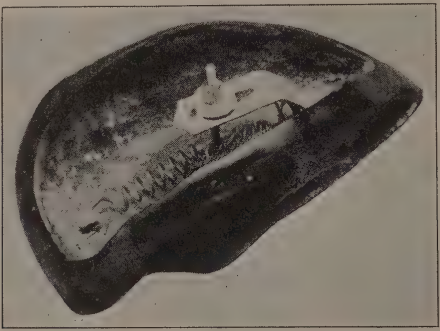

Fig. 868.—Obturator with spiral springs and other attachments in position. (McGehee.)

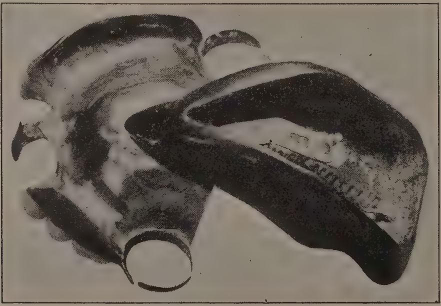

Fig. 869.—Another view of the appliance. (McGehee.)

"The plate and obturator are assembled by passing the upright screw-cut post on the backward extension of the plate, through the oblong hole already cut in the obturator, and also through the oblong hole provided for it in the clasp metal tongue in the upper hollow portion of the obturator. Now the nut previously provided for the purpose is screwed into place on the end of the upright post, bringing it into contact with the metal tongue of the obturator.

"The nut on the end of the upright post is loosened, the end of one spiral spring is attached to the anterior hook, the end of the other to the posterior hook and the opposite ends of both to the upright post; then the nut is screwed to the position which will give the metal tongue the proper tension to allow for the upward and downward movements of the obturator.

"The spiral springs extend along the under surface of the clasp metal tongue of the obturator and are given the proper tension to regulate the backward and forward movements of the obturator. Figs 868 and 869 afford an additional view of the completed appliance ready for use."

The Stearn Artificial Palate or Velum.—About twenty years after the time (1823) that Snell, in England, described his artificial palate or velum of elastic gum or caoutchouc (unvulcanized rubber), which has been previously mentioned as the first recorded attempt to provide a prosthetic appliance for congenital cleft palate, Dr. Stearn, of Springfield, Mass., a young graduate in medicine, devised and constructed for himself a most ingenious and quite complicated artificial palate of the velum type. This was reported by Kingsley as being highly successful, and a salient feature in its construction was the use of soft vulcanized rubber, the knowledge of which was undoubtedly obtained from Goodyear, who was at about that time conducting his experiments in the combination of sulphur with caoutchouc. The instrument, attached to a gold denture, was made in three parts—two lateral halves, divided by an antero-posterior slit, lying along and in contact with the sides of the cleft, with a sort of valve or flap on the lingual surface covering the slit to prevent the escape of the air column through it when in use.

A spring was provided to keep the flap in contact with the lateral halves, and the instrument was so attached to the plate that it could rise and fall with the movements of the muscles of the soft palate. Stearn considered the three-part construction as essential in providing for the contraction of the surrounding muscles, which Kingsley afterward found to be unnecessary.

Two principles enunciated by Stearn as applying to the operation of his device have been found to be vital to the success of all artificial vela and are here quoted:

"1. That the artificial velum should embrace the levator muscles of the palate so that it could be lifted by them.

"2. That it should bridge the upper pharynx behind the uvula and cut off nasal communication at will."

The Kingsley Velum.—In 1860, through acquaintance with Stearn, and in collaboration with him, Dr. Norman W. Kingsley, of New York, began the making of soft rubber vela of the Stearn type, of a simplified form, by a considerable modification of Stearn's technic, and finally, about five years later, produced the greatly simplified form of velum which he used for many years afterward in his practice and which has since been known by his name. It was made of soft vulcanized rubber attached flexibly to a supporting denture, and, therefore, quite freely movable by the muscles which engaged its sides, while its posterior border was so formed that it could be made to occlude readily with the ridge formed by the muscles of the pharyngeal wall, thus shutting off the nasal passage at will during speech and deglutition.

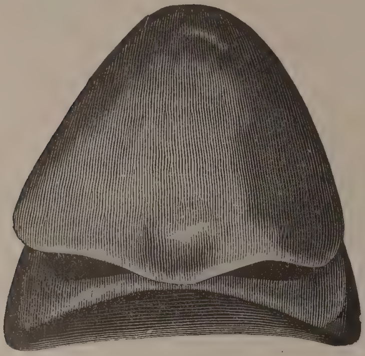

Fig. 870.

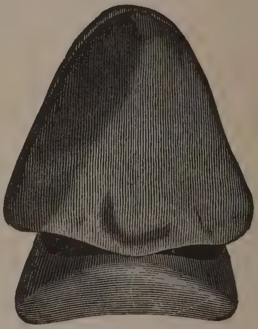

Fig. 871.

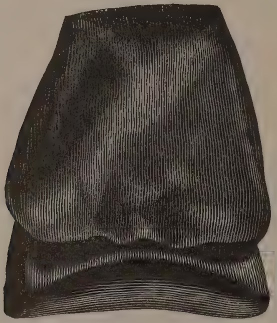

Fig. 872.

It is thus described by Ottolengui:[1]

"The Kingsley velum (Figs. 870, 871 and 872) consists of two flaps joined throughout the median line. The lower flap, the one which completes the palatal dome, extends from the apex of the fissure posteriorly as far as the bases of the uvulæ. Its general form is that of a triangle, the apex of which occludes with the apex of the cleft, the base extending across from one uvula to the other. This flap overlaps the soft parts sufficiently to prevent its being pushed through the cleft into the upper cavity. The other flap is of a similar triangular shape, the posterior border, however, being curved and thinned out to a feather edge, so that when in occlusion with the pharyngeal wall it curls up, thus presenting a flat surface for better contact, while its thinness prevents irritation to these sensitive parts. This flap is above the fissure and rests upon the upper surfaces of the divided palate. The two flaps are united along the median line, so that when complete they form a single appliance. The flaps having but a narrow line of union, grooves are produced laterally, and when in position the two halves of the soft palate rest in these grooves.

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[1] American Text-book of Prosthetic Dentistry, 1913, 4th ed., pp. 791, 792.

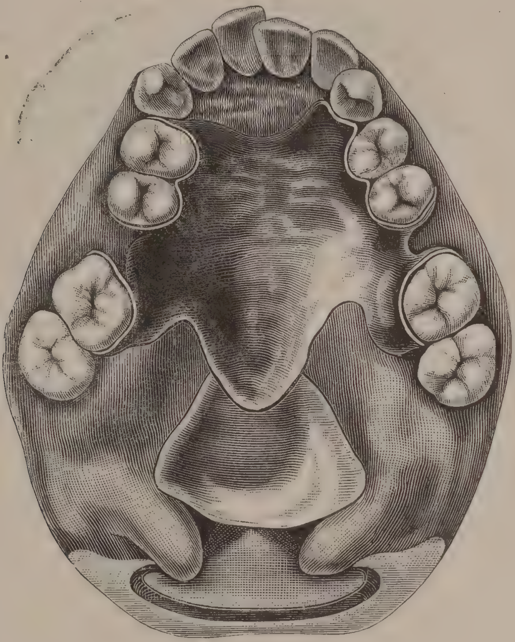

Fig. 873.

"In connection with the artificial velum a metal plate is constructed, clasped to the teeth, having a pin upon the upper surface which passes through a hole in the velum and thus holds it in place while allowing it lateral motion. Fig. 873 shows an instrument in position, the uvulæ appearing pendent below the grooves of the artificial palate. Note the relation between the posterior border of the velum and the wall of the pharynx. The *rationale* of this appliance is as follows: In the effort to close off the upper passage, the sides of the divided natural palate approximate each other, and at the same time are drawn upward. Thus they first hug the artificial velum tightly, and then, owing to its elasticity, carry it upward. Coincidently, the wall of the pharynx rises, forming a ridge which meets the feather edge of the artificial velum, curling it up, thus accomplishing perfect contact and completely preventing the escape of sounds through the nasal passages. At the same time the velum, completing the proper arch of the vault, is rigid enough to serve as an efficient abutment for the tongue when necessity compels such contact. Fig. 874 shows the upper view of the instrument seen in Fig. 873, and is introduced to give a clearer idea of the attachment of the velum to the plate, as well as the general character of the grooves.

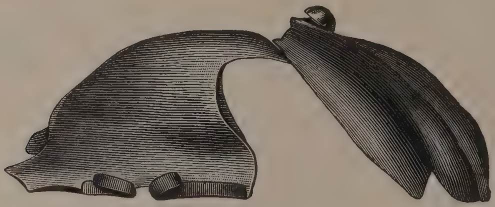

Fig. 874.

"As stated above, the flaps which constitute the velum are triangular in shape, yet it will be observed that the velum shown in Fig. 873 is square at the anterior end. Where the cleft is in the soft palate, only the triangular velum is required, but where the cleft passes forward, entering the hard palate, it is frequently more desirable to fill the aperture in the hard palate by vulcanizing hard rubber upon the upper side of the metal plate, the soft rubber velum having a square end to meet a similar surface of the hard rubber."

The Case Velum Obturator.—Reference has been made previously to the type of artificial palate advocated by Dr. Calvin S. Case, of Chicago, which requires no supporting structure, such support being provided at first, however, by means of a plate or similar device until the patient becomes accustomed to wearing the new palate, and then discarded. He has called this avelum obturator, the composite term apparently arising from the fact that it is designed to be made of soft rubber at first and later reproduced in hard rubber in the same molds. It was first presented to the profession at a meeting of the National Dental Association in 1902.

His description of the appliance, together with his technic for making the impression, and some of the construction details, follows:

"Through a desire to take advantage of the benefits afforded by a soft-rubber appliance on the one hand, and a hard-rubber obturator on the other, and at the same time avoid the possibilities of the final inefficiency of the one and the difficulties in construction and adjustment presented by the other, has risen the present artificial palate, which it is the object of this paper to present.

"It essentially consists of a form of palate which can first be made of soft rubber and possess all the advantages of the Kingsley velum, and then when the patient has become accustomed to it in its flexible state, and its form is an assured success, by packing the same casts in which the soft rubber palates were vulcanized with another quality of rubber, a hard-rubber palate is produced which possesses all the advantages of a perfect obturator.

"If made of softer rubber the first palate can be worn without irritation or special inconvenience; after which, desired changes in its form, that are nearly always required to perfect the palate, can then be easily made by slightly enlarging or contracting the metal mold in which it is vulcanized.

"Those who are familiar with the Kingsley dentures, which I am pleased to say I have used with great satisfaction in my practice for over twenty years, will remember that the veil or posterior portion of the palate is sustained by extending the central thickened portion into it, and from this point it is gradually flattened to a comparatively thin edge, where it is more or less curved in conformity to the pharyngeal wall, against which it is intended to rest during the contraction of the pharyngeal and the palatal muscles.

"In this particular it is quite different in form from the palate I am about to describe, in that with the latter all the central portion of the palate is thin, while the edge of the veil is thick, in the form of a solid roll $\frac{1}{5}$ inch in diameter, or preferably triangular, with rounded corners, so that its outer flattened surfaces exactly and firmly fit the pharyngeal walls *when the muscles are in a contracted state.*

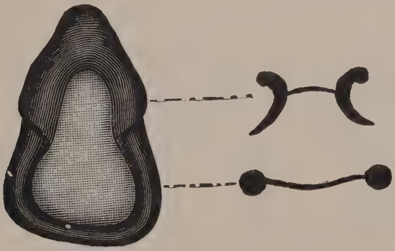

FIG. 875.

"Fig. 875 represents the palatal view of the artificial palate, with transverse section. Fig. 876 shows transverse sections through the mesial plane. Figs. 877 and 878 show the palate in position.

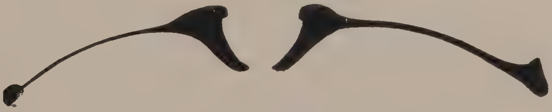

FIG. 876.

"In extensive clefts the borders of the veil extend forward along the lateral walls of the pharynx and posterior nares, and, becoming

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thinner, form the borders of the nasal extensions which rest upon the floor of the nares.

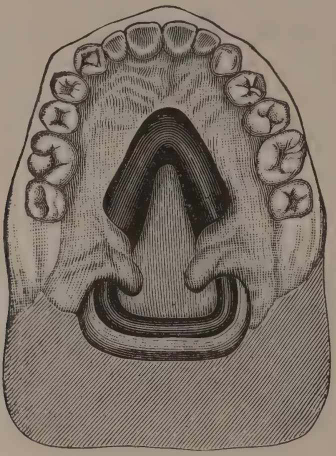

FIG. 877.

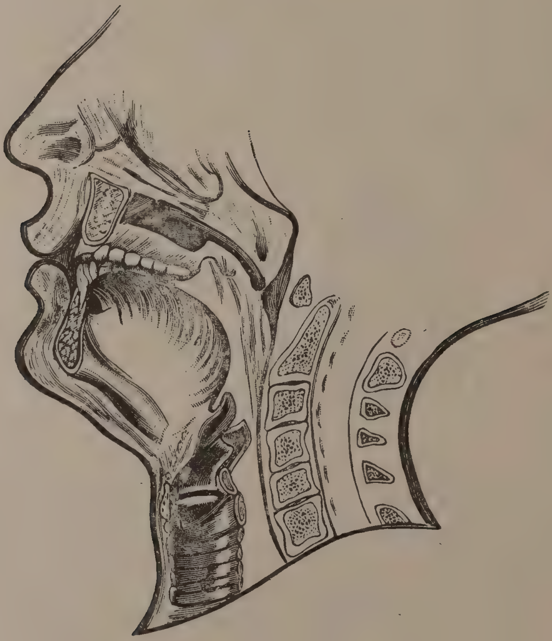

FIG. 878.

"When the cleft does not extend into the hard palate, the veil is shaped in a similar manner, but with the nasal portion abridged to meet the requirements of the case.

"Where the cleft extends into the hard parts, the body of the palate which covers the borders of the cleft and forms the lateral wings on the roof of the mouth should not extend back of the attachments of the bifurcated velum palati, nor in any way interfere with the free action of the muscles; neither should it extend upon the roof of the mouth any farther than is necessary to give a firm seating for the palate. This portion should be about as thick as an ordinary rubber plate, being thinned along its oral borders and thickened to form the nasal borders.

"There are a number of important advantages in this form of palate, even when made of flexible rubber and used for the purposes of a velum:

"1. The early deterioration of the rubber, causing the curling up of thin edges of the veil, is entirely prevented. When this occurs, as it frequently does with ordinary vela, the vocal usefulness of the palate is impaired—if not destroyed—in proportion as it permits the escape of air at the curled-up portion of the border.

"2. The heavy border of the veil is sufficiently yielding and flexible to be worn with comfort if properly fitted, and it also presents sufficient stability and breadth of surface to permit firm contact of the pharyngeal muscles in closing the nasopharyngeal opening.

"3. In more or less extensive clefts the thin central portion extending forward into the body of the palate permits a resilient yielding of the lateral portions of the body, which frequently allows one to spring it into place with sufficient grasp of the irregular borders, along which it should accurately fit, to hold it in position without the aid of a supporting denture. Whenever this can be accomplished with the soft palate, it will readily be continued when it becomes hard."

The technic of making metal molds from the modeling compound, or other pattern of the velum, in which to vulcanize has been described in previous pages, to which the reader is referred.

Ottolengui's Velum Obturators.—Dr. R. Ottolengui, of New York, has made some modifications of the Kingsley velum, and a type of obturator made of soft rubber, both of which he terms velum obturators.[1] His description of these and portions of his technic are quoted:

"In 1902 I constructed a new form of instrument which apparently falls under the term 'velum obturator,' in that it has the compound action of both. A patient came into my hands for a new instrument, the one made for her by Dr. Kingsley some ten years previously having lost its usefulness. I had known the lady when her first instrument was made, and was well aware of the improvement it had made in her speech. I was not prepared, however, for the curious condition which I found had resulted from its use. The velum had fitted perfectly when first adjusted, the palatal flaps spanning the gap and resting lightly against the split soft palate, while the nasal flap rested above and extended posteriorly in such a way that the sides of the divided palate, when brought into action, would slide between the flaps, and throw the posterior flap upward, its thin edges turning upward to occlude the passage of the nares, this, of course, being the intended object of the Kingsley velum (Fig. 873). An examination, however, disclosed the fact that the instrument was not so operating. The muscles of the pharynx had so increased in activity that in the closure of the throat their contraction would entirely extrude the soft-rubber velum, so that the nasal flap lay constantly toward the palatal side of the fissure, and therefore became merely a useless mass of rubber which served no practical purpose.

---

[1] American Text-book of Prosthetic Dentistry, 4th ed., 1913, pp. 808, 830, 836.

"In this dilemma I conceived the idea of constructing an instrument, the nasal flap of which should be just the reverse of the Kingsley appliance. Instead of forming the nasal flap with thin tapered edges, slightly turned upward (Figs. 870, 871, 872 and 873), so that in the closing of the throat these edges would be everted, thus presenting a broad surface contact to the walls of the pharynx, I undertook to fashion a soft-rubber appliance with a posterior or nasal flap, having its most posterior surface so formed that when the pharyngeal muscles should close upon it, there would be broad and equal surface contact, thus effectually occluding the passage to the nares, and so obviating the escape of sounds in that direction.

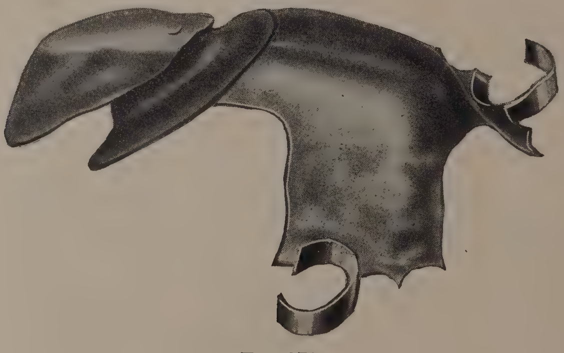

Fig. 879.

"Fig. 879 shows the first instrument of this character made by me. Comparison of this illustration with Fig. 874 will show that the nasal flap of my instrument is exactly the reverse of that in Dr. Kingsley's. In the Kingsley appliance the throat muscles must evert the thin edges of the velum, and so produce contact and occlusion of the nasal passages, while in my instrument the soft-rubber nasal flap is of just such size and shape that, remaining quiescent, the pharyngeal walls in closing come into accurate contact with it. Being made of elastic material, any increased activity of the throat muscles will be compensated for by the fact that the appliance is pliable, and in this respect closely resembles the natural organs as they are when normal. . . .

"An analysis of the following description of the construction of my own 'velum obturator' will disclose that it is exactly what its name implies, and that the method of producing it is but a combination of the technics already described for soft-rubber vela, and for hard-rubber obturators. In obtaining a wax model for the hard-rubber obturator, it will be recalled that we first made the metal carrying plate, soldered a loop of copper wire temporarily to the upper surface thereof, molded composition about this wire loop and obtained an impression of the pharyngeal region by introducing this into the mouth with the composition soft, and then having the patient swallow. This compound impression was then itself used as the model for the hard-rubber obturator, with certain alterations in shape, which have been already described. In constructing a soft-rubber velum obturator the technic differs slightly, as it is advisable to produce a plaster model of the parts; one which, as already insisted upon, will show the anterior position of the mouth at rest, and the posterior or pharyngeal region closed.

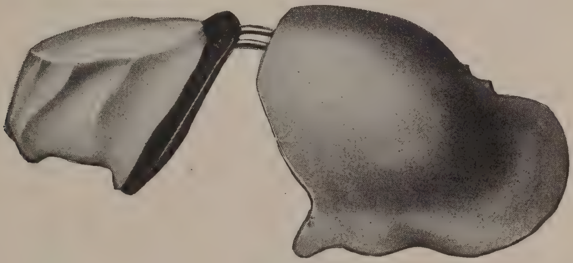

FIG. 880.

"In the first case treated by me, after obtaining the plaster model in the usual manner, I then fashioned a trial plate of gutta-percha, using two thicknesses to afford greater stability. Between the two layers I placed the ends of a copper wire loop, this loop extending backward and being bent to follow the curve of the palate. This gave me a trial plate similar to the metal plate used in this part of the technic of making a hard-rubber obturator.

"It is not absolutely essential to have this wire loop, but it is an added safeguard against dislodgement of the wax which is to be used for taking the impression of the throat, and leaves the operator fairly certain that the patient will not swallow the mass of wax, an accident not at all impossible.

"In the case under description the cleft in the palate was so far back that the copper wire was also a convenience in spanning the gap between the posterior border of the hard palate and the anterior border of the cleft (Fig. 881). The wire loop was then wrapped with a mass of ordinary beeswax and formed into a mass approximately a little too large for the cleft. This was then softened in warm water, introduced to place and held in the mouth with the forefinger while the patient was instructed to swallow repeatedly. When removed, this wax afforded an approximate, not an accurate, impression of the pharynx when closed. It might be accurate, and it might not, depending upon the strength of the parts to compress the wax fully. However, an approximate impression is all that is needed at this stage. Next a considerable portion of the surface of the wax is cut away, and so cut that the surface is left quite rough. It must also be trimmed away sufficiently so that when introduced, and the patient is allowed to swallow, he will report that he does not feel it.

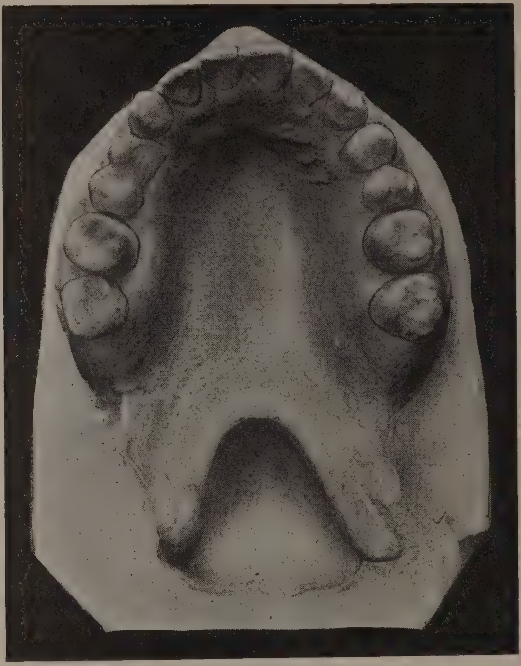

Fig. 881.

"This wax mass is then covered with a layer of creamy, quick-setting plaster of Paris, is placed in the mouth and the patient again asked to swallow repeatedly. There is no danger of the plaster dripping down the throat unless altogether too much plaster is used. Indeed, in handling plaster in the mouth an excess should never be introduced. However, as an additional precaution, the operator may have at hand two or three swabs, made by wrapping cotton around the end of sticks of orangewood. With these swabs *dry,* if any plaster should be seen to trickle downward, it can be quickly and deftly wiped away.

"Fig. 880 shows the trial plate removed with the plaster impression of the pharyngeal opening which is left by the contraction of the muscles. This gutta-percha plate, having been accurately made on the already constructed model is readily replaced thereon, and the impression of the pharyngeal region will extend back beyond it. The plaster used in taking this impression should be slightly colored by adding paint powder to the mixing water, or else it should be thoroughly varnished with shellac, followed by sandarac. The trial plate carrying the impression, having been placed on the model, additional plaster is added to the posterior part of the model so as to completely surround the impression. Later, when thoroughly hard and the impression was removed the result was the model seen in Fig. 881, which shows the hard and soft palatal regions *at rest,* and the pharyngeal muscles *contracted.*

"On this plaster model a wax model of the velum obturator is formed, having secured which, metal molds are made from the wax model exactly as has been described for making a Kingsley soft velum. The velum obturator made for my first case is seen in Fig. 879 attached to its metal carrying plate. In Fig. 880 it will be observed that there is a flat or plane surface on the top of the plaster impression. This, of course, is not as it would be when removed from the mouth, but it has been so trimmed for comparison with the velum obturator.

"In the main there may be said to be three classes of cleft-palate cases which may come to us for treatment. Those in which the cleft is in the soft palate only; those in which the hard palate is also involved; those resulting from failures of surgeons.

"I am glad to say that thus far I have been successful with my new instrument in all three conditions.

"There is one advantage of this velum obturator which is worth recording. Being made in larger masses than the Kingsley velum, the soft rubber is not so quickly destroyed by the fluids of the mouth, nor is it distorted by curling up. It, therefore, requires renewal less frequently."

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